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INSTITUTE OF THE AERONAUTICAL SCIENCES

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Space Technology and the NACA

. . . an Editorial by Hugh L. Dryden

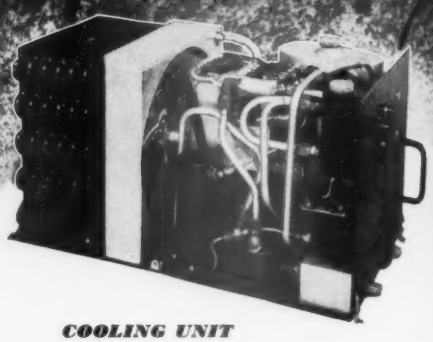
March, 1958

cooling avionic systems

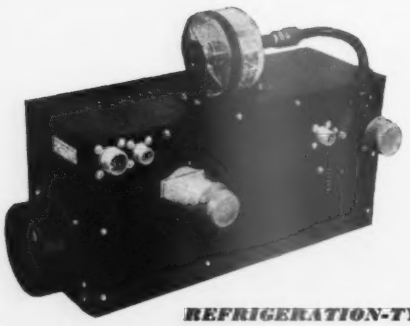
During World War II, Eastern Industries pioneered cooling systems for aircraft electronic systems. Now, thousands of installations later, and as the leader in this challenging field, Eastern is still pioneering.

Experience has been a springboard to new developments . . . compactness, simplification, refrigeration cycles. Research and development continue to play their vital parts in perfecting systems to overcome the new problems as expanded aircraft performance produces fantastic rises in temperatures.

If you have a challenging problem, come to the leader in the field for complete and creative engineering help.



COOLING UNIT



REFRIGERATION-TYPE

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Custom-made units, with or without refrigeration cycles, provide a method of maintaining safe operating temperature limits in electronic equipment. Standard sub-assemblies and components normally are used to create a custom-made design to fit your exact needs. Costs are minimized for these completely self-contained units by combining heat exchangers, fans or blowers, liquid pumps, reservoirs, flow switch, thermostat, and other common components.

Write for Eastern AVIONICS BULLETIN 340

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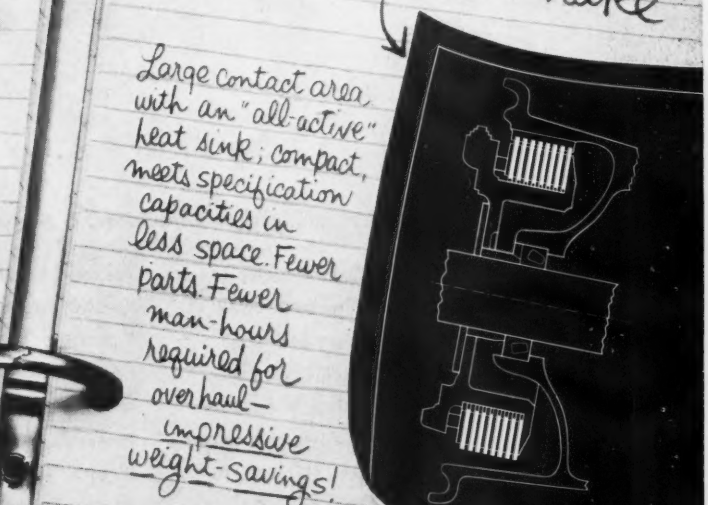

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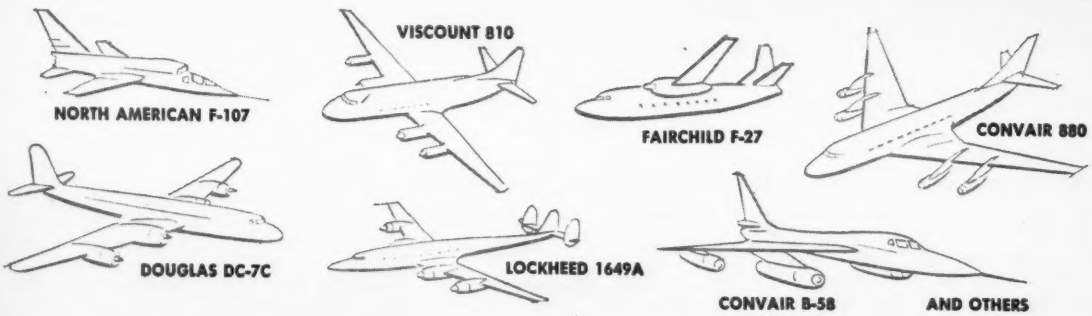

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Aeronautical Engineering Review

Vol. 17—No. 3 March, 1958

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Cover—Grumman Aircraft Engineering Corporation will produce for the Navy an undisclosed number of WF-2 Tracer early-warning aircraft according to Grumman President Leon A. Swirbul. The carrier-based, all-weather aircraft is said to have the largest radome yet designed for a carrier-based aircraft. Electronic detection equipment is supplied by Hazeltine Electronics Corporation. Two pilots and two warning system operators make up the crew. A modified version of the WF-1 Trader, the Tracer differs from its predecessor in the saucer-like radome and twin-fin tail.

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IAS News Notes

March 1958

NEW FILM LIST: The fourth annual edition of the Giannini Film List (revised) includes more than 100 new titles of films dealing with contemporary technical phases of aeronautics. Copies may be obtained free of charge by writing IAS National Headquarters in New York.

NATIONAL MEETINGS CALENDAR

Mar. 13-14	Flight Propulsion Meeting (Classified) Hotel Carter, Cleveland.
Mar. 17-21	1958 Nuclear Congress, International Amphitheatre, Chicago. IAS participating.
Apr. 28-30	Second Annual AFOSR Astronautics Symposium, Shirley-Savoy Hotel, Denver, Col. Sponsored by IAS.
May 12-14	National Conference on Aeronautical Electronics, Dayton, Ohio. IRE-IAS participating.
May 12-14	Midwestern Conference on Guided Missiles, Hotel Chase, St. Louis.
June 2-4	National Telemetering Conference, Lord Baltimore Hotel, Baltimore, Md. Sponsored by IAS, ARS, ISA, and AIEE.
June 19-20	1958 Heat Transfer and Fluid Mechanics Institute, University of California, Berkeley. Cosponsored by IAS.
July 8-11	National Summer Meeting, Ambassador Hotel, Los Angeles, Calif.
Sept. 8-13	First International Congress, International Council of the Aeronautical Sciences, Palace Hotel, Madrid, Spain.
Oct. 7-8	Canadian Aeronautical Institute-IAS 1958 Joint Meeting, Chateau Laurier, Ottawa, Canada.
Dec. 17	Wright Brothers Lecture, Washington, D. C.
1959	
Jan. 26-29	Twenty-Seventh Annual Meeting, Sheraton-Astor Hotel, New York. Honors Night Dinner, Tuesday, January 27.

REGIONAL STUDENT CONFERENCES

Mar. 22	Northeastern: Stevens Institute of Technology, Hoboken, N. J.
Apr. 10-11	Southeastern: Atlanta, Georgia. Sponsored by Atlanta Section.
Apr. 18-19	St. Louis: St. Louis, Mo. Sponsored by St. Louis Section.
Apr. 24-26	Texas: Dallas, Texas. Sponsored by Texas Section.
May 1-3	Middle-Atlantic: Pennsylvania State University, University Park, Pennsylvania.
May 6	Detroit: University of Michigan, Ann Arbor, Michigan. Sponsored by Detroit Section.
May 7-9	West Coast: Los Angeles, California. Sponsored by Los Angeles Section.

* * * * *

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ANNOUNCEMENT

FIRST INTERNATIONAL CONGRESS IN THE AERONAUTICAL SCIENCES

under the auspices of

INTERNATIONAL COUNCIL OF THE AERONAUTICAL SCIENCES

MADRID, SPAIN 8 - 13 September 1958

Since the Fall of 1956 the Institute has been cooperating with many countries in the organization of the International Council of the Aeronautical Sciences (ICAS). A provisional organization has been formed under the Presidency of Theodore von Karman, with M. Maurice Roy (ONERA) France, as Chairman of the Executive Committee. The IAS has been designated as the permanent Secretariat. Financial support will derive from the Institute's Daniel and Florence Guggenheim Memorial Fund.

To date 18 countries having organized technical societies are planning to participate in the First Congress of ICAS to be held in Madrid, Spain, 8-13 September 1958. Participation by other countries is anticipated.

The program committee for the First Congress has selected approximately 40 papers for the tentative program below.

Monday, September 8 --- Opening Session

Daniel and Florence Guggenheim International Memorial Lecture ---------- Th. von Karman
Juan de la Cierva Lecture ---------- Ing. Pedro Blanco

Tuesday, September 9 --- General Session

Aerodynamic Design for Supersonic Speeds ---------- R. T. Jones (U.S.)
Telecommand and Navigation ---------- W. H. Stephens (U.K.)
Propulsion Supersonics ---------- M. Roy (France)

Special Session - Hypersonic Flow

Newtonian Flow Theory in Hypersonic Aerodynamics ---------- W. D. Hayes (U.S.)
Dynamics of a Dissociating Gas ---------- M. J. Lighthill (U.K.)

Special Session --- Structures and Aeroelasticity

Papers by A. van der Neut (Holland); L. Broglio (Italy); R. Mazet (France); and Marten T. Landahl (Sweden)

Wednesday, September 10 --- Special Session --- Heat Transfer and Heat Barrier

Mass Transfer Cooling, A Means to Protect High Speed Aircraft ---------- E. R. G. Eckert (U.S.)
The Heat Barrier and its Influence on Hypersonic Aerodynamics ---------- R. J. Monaghan (U.K.)
Non Adiabatic Flow of a Gas in a Rotating Duct ---------- Manuel de Sendasorta (Spain)
Two papers on Heat Transfer by R. Siestrunck and J. J. Bernard (France); and E. Schmidt (Germany)

Special Session --- Jet Engines and Noise

Jet Engines and Noise Papers by F. B. Greatrex (U.K.); H. S. Ribner, K. K. Neely and B. Etkin (Canada); William Littlewood (U.S.); and H. Le Boiteux (France)

Special Session --- Navigation and Guidance

Some Considerations of Safety in Instrument Flight Control ---------- A. M. A. Majendie (U.K.)
On Dynamically Caused Drift Effects of Gyro-Systems ---------- K. Magnus (Germany)
Inertial Navigation ---------- C. S. Draper (U.S.)

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Special Session --- Boundary Layer Control

Boundary Layer Control Papers by H. Schlichting (Germany); G. V. Lachmann (U.K.): and M. P. Carriere and P. Poisson-Quinton and E. A. Eichelbrenner (France)

Thursday, September 11 --- General Session

Aeroelastic Problems of Aircraft Construction ----------H. G. Küssner (Germany)
A Review of Some Recent Developments in Hypersonic Flow----------A. Ferri (U.S.)

Friday, September 12 --- Special Session --- VTOL-STOL

VTOL and STOL Airplanes Papers by J. P. Campbell (U.S.); D. Keith-Lucas (U.K.); and Mon. Eggers (France)

Special Session --- Heat Resistant Materials

Materials and Structures for Finite Lifetime----------N. J. Hoff (U.S.)
Problems in Heat Resistant Materials for High Speed Flight and Propulsion--------Pol Duwez (U.S.)

Special Session --- Human Engineering

Papers by D. G. Simons (U.S.); G. Melville Jones (U.K.); and M. E. Evrard (Belgium)

Special Session --- Telecommand and Telemetering

Transmission of Data by Radio from the U.S. Satellites ----------J. T. Mengel (U.S.)

Saturday, September 13 --- General Session

Propulsion Methods in Astronautics ----------W. Bollay, (U.S.)

INFORMATION FOR DELEGATES

Delegates wishing to attend this meeting should apply to their own participating society for application forms and further information. The participating societies and organizations are listed below.

Viajes Marsans, Carrera de San Jeronimo, 19 Madrid, Spain, will handle room reservations, and a special form will be sent to delegates by their society. Delegates should make their own travel arrangements. Travel Center of Manhasset, 580 Plandome Road, Manhasset, N. Y., has been appointed to handle travel reservations for the American delegation.

AUSTRALIA--Australian Div. of R. Ae. S., L. P. Coombes, Aero. Res. Lab., Box 4331, GPO, Melbourne.
BELGIUM--Y. Hamal, A.B.I.T.A., Aerodrome de et a Melsbroek.
CANADA--Gr. Capt. H. R. Foottit, Pres., CAI, 801 Commonwealth Bldg. 77 Metcalfe St. Ottawa 4.
DENMARK--Ove Guldberg, Sec'y., Inst. of Danish Civil Engrs., Vester Farimagsgade 29, Copenhagen V.
FRANCE--M. J. Jarry, Pres., A.F.I.T.A., 6, Rue Cimarosa, Paris 16.
GERMANY--Prof. Dr. H. Blenk, Pres., WGL, E.V., Braunschweig, Bohlweg, 1-2.
ISRAEL--Dr. Josef Singer, Israel Society of Aeronautical Sciences, P. O. Box 2956, Tel-Aviv.
ITALY--Prof. Enrico Pistolesi, Pres., Associazione Italiana di Aerotecnica, Direzione: Pisa.
JAPAN--Dr. H. Kimura, Pres., J. Soc. of Aero. Engrs., Hikokan, Tamura-cho 1-chome, Minato-ku, Tokyo.
NEW ZEALAND--N. Z. Div. RAeS, Air Com. G. N. Roberts, Pres., 96 Stevens Av., Parnell, Auckland C. 4.
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SPAIN--Colonel Antonio Perez-Marin, INTA, Serrano 43, Madrid.
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TURKEY--Mr. M. Aksam, Dept. of Aero., Inst. of Civil Av., Technical Univ. of Istanbul, Istanbul.
UNITED KINGDOM--Dr. A. M. Ballantyne, Sec'y, R. Ae. S., 4 Hamilton Place, London, W. 1.
UNITED STATES-- S. Paul Johnston, Director, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21.

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MEMBERS MAY HEAR the Minta Martin Lecture, "Combustion - An Aeronautical Science" by H. W. Emmons, at M. I. T. on March 10; at the University of Maryland on March 17; and at California Institute of Technology on March 20.

SECTION MEETINGS CALENDAR

Mar. 3 Indianapolis Section: Dinner Meeting, Mirror Room, Marott Hotel, (Social at 6:30, dinner at 7) "Flying and Operational Aspects of the McDonnell F-101 Airplane" by D. H. Stuck.

Mar. 4 Hampton Roads Section: Dinner Meeting, Williamsburg Room, Langley AFB Officers Club. (Social at 6:30, dinner at 7:30) "Development and Procurement of Naval Aviation" by Vice Adm. James S. Russell.

Mar. 6 Atlanta Section: Dinner Meeting, Hellenic Center. (Social at 6, dinner at 7) "Human Factors for Advanced Weapon Systems" by A. W. Hetherington.

Mar. 6 San Diego Section: Technical Meeting, IAS Building, 8 p.m. "Boundary-Layer Control" by F. G. Wagner.

Mar. 10 Boston Section: General Meeting, M. I. T. Kresge Auditorium, 8 p.m. The Minta Martin Lecture by H. W. Emmons.

Mar. 11 Los Angeles Section: Specialist Meeting, IAS Building, 7:30 p.m. "Aerodynamics at Extreme Altitude" panel discussion with W. W. Kellogg, J. V. Charyk, and Carl Gazley.

Mar. 12 Seattle Section: General Meeting, Olympic Hotel, 8 p.m. "The Future of Jets" by Dan Kimball.

Mar. 13 Baltimore Section: Dinner Meeting, Applied Physics Lab., Howard County, Md., 7 p.m. CLASSIFIED. "The Future of Missiles" by Simon Ramo.

Mar. 14 San Antonio Section: Dinner Meeting, Kelly AFB Officers Club, 6:30 p.m. "Beaten Paths are for Beaten Men" by Harold Vagtborg.

Mar. 19 Chicago Section: Dinner Meeting, Illinois Institute of Technology, 6:30 p.m. "Test Flying of Supersonic Aircraft" by W. J. Cochran. (Annual Student Meeting).

Mar. 20 Los Angeles Section: Dinner Meeting, IAS Building, (Social at 6, dinner at 7) Minta Martin Lecture by H. W. Emmons.

Mar. 20 Rocky Mountain Section: Dinner Meeting, The Tiffin (Writers' Manor), Denver, (Social at 6:30, dinner at 7:30) "Planning for Future Air Defense Command Weapons" by Major Kemper Baker.

Mar. 25 Los Angeles Section: Specialist Meeting, IAS Building, 7:30 p.m. "Compressible Turbulent Boundary Layer with Heat Transfer" by E. Reshotko.

Mar. 25 Kansas City Section: Dinner Meeting, TWA Lobby, Mid-Continent Airport, Parkville, Mo. (Registration at 6, dinner at 6:30) "Bring on the Jets" by R. M. Dunn. (Also visit to TWA facility).

Mar. 27 Texas Section: General Meeting (with AHS), place to be announced, 7 p.m. "X-14 Convertiplane" by J. A. O'Malley.

Mar. 27 San Diego Section: Specialist Meeting, San Diego State College, 8 p.m. "Effect of Nuclear Radiation on Organic Materials" by R. O. Bolt.

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IAS News

A Record of People and Events of Interest to Institute Members

Annual Business Meeting of the Institute

Reports of President, Treasurer, and Director

THE TWENTY-SIXTH ANNUAL MEETING of the members of the Institute was held at the Hotel Sheraton-Astor, New York, on January 29, 1958. Mundy I. Peale, President, presided.

Elmer A. Sperry, Jr., Teller, reported that he had received and counted 1,643 valid proxies for voting at the Annual Meeting—a quorum of the voting membership.

Charles H. Colvin, Chairman of the Nominating Committee, placed in nomination the following members for election to vacancies on the Council:

Edward C. Wells, Mundy I. Peale, Neil Burgess, Gen. B. W. Chidlaw, USAF (Ret.), L. Eugene Root, Horton Guyford Stever, and R. Dixon Speas, for a term of 1 year each; Preston R. Bassett, R. C. Blaylock, C. M. Bolster, L. de Florez, and William Littlewood, for a term of 3 years each; T. F. Walkowicz for a term of 2 years; and the following area councilors for a term of 1 year each: Eastern Area—F. N. Dickerman and I. G. Ross; Central Area—K. L. Burroughs and G. R. Gehrkens; Western Area—L. T. Goodmanson and Earl R. Hinz. On motion duly made, seconded, and carried, they were unanimously elected. The following were nominated and elected in like manner to serve on the Nominating Committee for 1958: P. R. Bassett, Chairman, C. M. Bolster, H. L. Dryden, C. C. Furnas, C. J. McCarthy, Jack Parker, A. E. Raymond, and R. C. Sebold.

The Annual Reports of the President, Treasurer, and Director were read and approved. (See the following pages for the complete reports.)

The Secretary presented a list of honors conferred by the Institute in 1957 as follows:

The Octave Chanute Award to Lt. Col. Frank K. Everest, Jr., USAF, Armed Forces Staff College; the John J. Jeffries Award to Major David G. Simons, USAF (MC), Holloman Air Development Center; the Robert M. Losey Award to Prof. Jule G. Charney, Department of Meteorology, Massachusetts Institute of Technology; the Sylvanus A. Reed Award to Prof. Raymond L. Bisplinghoff, Department of Aeronautical Engineering, Massachusetts Institute of Technology; the Lawrence A. Sperry Award to Clarence A. Syvertson, Assistant Chief, 10 × 14 in. Supersonic Wind Tunnel Branch, High Speed Research Division, Ames Aeronautical Laboratory, NACA; the Minta Martin Aeronautical Student Fund-National Paper Awards to: Graduate Division—Herman Mark, Cornell University; Undergraduate Division—Samuel J. Harris, III, Virginia Polytechnic Institute; the Water-Based Aviation Award to John B. Parkinson, Chief, Hydrodynamics Division, Langley Memorial Laboratory, NACA; and the Wright Brothers Lecturer, H. Julian Allen, Chief, High Speed Research Division, Ames Aeronautical Laboratory, NACA, who spoke on "Hypersonic Flight and the Re-Entry Problem."

Honorary Fellowships in the Institute to: American—William Littlewood, Vice-President, Equipment-Research, American Airlines, Inc.; Foreign—Bo K. O. Lundberg, Director, Aeronautical Research Institute of Sweden.

Fellowships in the Institute to: Raymond C. Blaylock, Vice-President—Engineering, Chance Vought Aircraft, Inc.; Adolf Busemann, Staff Scientist, Langley Aeronautical Laboratory, NACA; Milton U. Clauser, Director, Aeronautical Research Laboratory, The Ramo-Wooldridge Corporation; Lt. Gen. Laurence C. Craigie, USAF (Ret.), Vice-President, American Machine & Foundry Co.; Luigi Crocco, Robert H. Goddard Professor of Jet Propulsion, Princeton University; Brig. Gen. Marvin C. Demler, USAF, Deputy Commander R&D, Headquarters ARDC; I. E. Garrick, Chief, Dynamic Loads Division, Langley Aeronautical Laboratory, NACA; Roy E. Marquardt, President, Marquardt Aircraft Company; Raymond C. Sebold, Vice-President—Engineering, San Diego Division, Convair; Hartley A. Soulé, Assistant Director, Langley Aeronautical Laboratory, NACA.

The Secretary announced that the Council had elected the following officers of the Institute for 1958: President, Edward C. Wells; Vice-Presidents, Neil Burgess, Gen. B. W. Chidlaw, USAF (Ret.), L. Eugene Root, and Horton Guyford Stever; Treasurer, R. Dixon Speas; Director, S. Paul Johnston; Secretary, Robert R. Dexter; and Controller, Joseph J. Maitan.

ROBERT R. DEXTER
Secretary

President's Report—1957

IN 1957, the year in which world attention has been so dramatically fixed upon the progress of the aeronautical sciences, the scope and pace of activities of the Institute of the Aeronautical Sciences have been very appropriately broadened and quickened. Complete details of the year's activities are to be found in the reports of the Director and the Treasurer.

Once again the Institute ends a year in a sound fiscal position, and it is a pleasure to report that our membership is at an all-time high. Satisfying gains have been made both in upgrading qualified members and in swelling the ranks of student members by 1,000 for the year—a significant gain because in it lies our hope for future growth and accomplishment. In each of the year's activities, new records of attendance, interest, and worth-while participation were established, and the program for 1958 promises even greater activity.

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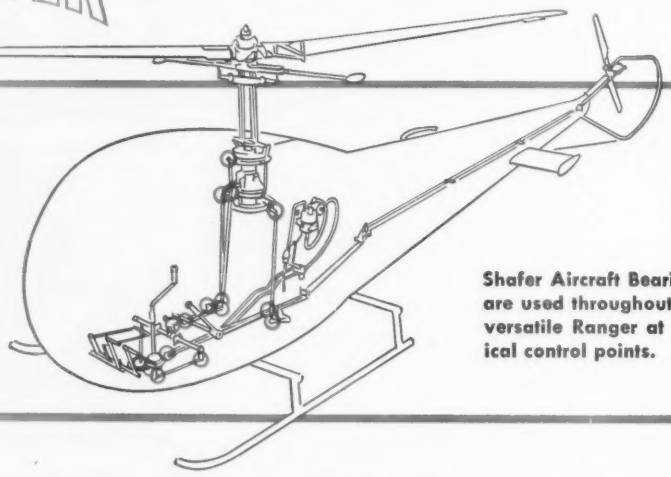

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SHAFER® CHAIN BELT COMPANY

Two important "firsts" were instituted by the IAS last year, both holding promise of expanded and valuable future activity. One was the National Naval Meeting, held in San Diego, Calif., and the other was the Weapons System Management Meeting, held in Dallas, Tex., the first of a new series of National Midwestern Meetings.

The Naval Meeting, featuring 4 days of valuable technical sessions designed to bring our organization and the industry closer to the overall developments and objectives of our Navy's aviation arm, included a cruise aboard the carrier U.S.S. "Ticonderoga" and was attended by more than 2,000. The Institute's Water-Based Aviation Award was presented to John B. Parkinson of Langley Memorial Laboratories, NACA, for sustained leadership in research on the hydrodynamics of water-based aircraft.

The first of the Midwestern Meetings, which will broaden the geographic base of important Institute functions and can be used to cover the entire field of the aeronautic sciences, was completely set up by the members of the Texas Section; it comprised 15 technical sessions and a stimulating panel discussion. A second meeting of this series, devoted to technology of guided missiles, is planned for May of this year at St. Louis and will serve to bring the fruits of Institute thinking to great numbers of the membership working in the middle section of the country.

The vigor that marked so much of our work this year was perhaps best exemplified in the Institute's National Summer Meeting in Los Angeles, where a 50 per cent increase in the number of technical sessions—13 in all—necessitated the conducting of sessions simultaneously for the first time. The Annual Flight Propulsion Meeting, held in Cleveland last March, drew the largest audience in the eleven-year history of these classified, Air Force-sponsored programs. Another highlight of the year was the delivery of the IAS Wright Brothers Lecture by H. Julian Allen, an aeronautical research scientist who recently received the NACA's highest honor, the Distinguished Service Medal. More than 600 persons, a record for this lecture, attended. Earlier in the year, the IAS contribution to the Institute of Radio Engineers' National Conference of Aeronautical Electronics comprised the greatest to date—three sessions and 15 technical papers.

A further expansion of our activities was agreement to have the Institute sponsor the Second Annual Astronautics Symposium of the U.S. Air Force Office of Scientific Research, this year in Denver.

In the international field, it was my honor last year to lead one of the largest delegations of American members ever to attend an Anglo-American Aeronautical Conference away from home. It is a pleasure to report that the Americans' contributions in technical papers and panel discussions contributed greatly to the overall success of the highly diversified program at Folkestone, England. We extended an invitation to our widening circle of British friends to be our guests at the seventh of these valuable biennial meetings in America in 1959.

The Institute continued to cooperate closely with the fledgling Canadian Aeronautical Institute in staff work and the free exchange of ideas and technological information, and a scientist who was elected an IAS Fellow—Gordon N. Patterson of the University of Toronto—delivered the W. Rupert Turnbull Lecture at the Fourth Annual CAI-IAS International Meeting at Montreal last fall.

Perhaps the most important step in international affairs was the decision to have the Institute take the important role of permanent secretariat in the International Council of the Aeronautical Sciences and to take an active part in planning and providing the operating staff for its first International Congress of Aeronautics in Madrid, Spain, next September. When Honorary President Theodore von Kármán calls the Congress to order, he will launch the first truly worldwide meeting of space scientists and engineers ever brought together to facilitate the free exchange of ideas—the purpose for which the IAS was founded. A special contribution to efforts of the International Council is being made through the Institute by utilizing a substantial donation by Harry Guggenheim, an IAS Honorary Fellow. In this manner, the ICAS has established the Daniel and Florence Guggenheim International Memorial Lecture, to be presented by one of the world's leading aeronautical scientists at each future biennial International Congress. The Congress will be held without regard to military or political interests, and every country dedicated to the advancement of the aeronautical sciences will be welcome to participate.

The growth of our Sections and Branches in the IAS has been healthy and vigorous. The services of our key facilities and activities, such as the Gabriel M. Giannini Film Library and the Minta Martin Student Fund, are receiving ever-widening use by the membership and are constantly broadening in context. You have seen how our activities on this continent and abroad are expanding on a sound and continuing basis in pursuit of the Institute's basic objectives—the seeking of truth in the sciences and the propagation of our technological knowledge.

All of these milestones of aeronautical progress point in the right direction. However, today we find ourselves in most extraordinary times. This is a time of urgency, and, as I turn the gavel of this high office over to my successor, it is with the plea that a sense of urgency will become the watchword of our Institute and its members in the years to come. This urgency we must apply to our daily work and to help expedite in every way we can the creation of a better, larger, and more productive educational program in America in the scientific arts.

It has been an honor to serve as your president, and you have my pledge to continue to work for the progress of our organization, its membership, and the nation we serve.

MUNDY I. PEALE
President, 1957

Treasurer's Report—1957

THE OPERATIONS of the IAS for the year ending September 30, 1957, resulted in a net unexpended income of $8,562.34 as detailed on the accompanying Consolidated Balance Sheet and Operating Statement. (See p. 18.)

All activity was on a higher level as referenced in the President's and Director's Reports and is generally reflected in higher operational costs over the preceding year.

To review our Balance Sheet briefly, the unrestricted investments were increased $25,000 to $527,800; restricted fund investments totaled $1,114,200. The market value of $1,865,000 of the total portfolio, which includes the specific Funds, is $223,000 in excess of cost or book value. The substantial appreciation in value of these holdings, considering the significant stock market decline last fall, is attributable to the good judgment exercised by the Finance Committee in their selection of investments.

A capital improvement consisting of an addition to the Los Angeles Building was completed, and the space was occupied by the AIA in November, 1956. The cost is being amortized over a 4-year term.

There were no significant changes in the Principal balances of the various restricted Funds. The income is expended in accordance with the donors' conditions when establishing the Fund.

The direct costs of meetings which are expanding in both numbers and volume

XUM

IAS Officers for 1958

STAFF OFFICERS FOR 1958

S. Paul Johnston, Director

Robert R. Dexter, Secretary

Joseph J. Maitan, Controller

PRESIDENT

Edward C. Wells

Vice-President—Engrg.
Boeing Airplane Co.

VICE-PRESIDENT

Neil Burgess

Manager, J-79 Project
Aircraft Gas Turbine Div.
General Electric Co.

VICE-PRESIDENT

General B. W. Chidlaw USAF (Ret.)

Vice-Pres. and Director
Thompson Products, Inc.

VICE-PRESIDENT

L. Eugene Root

General Manager
Missile Systems Div.
Lockheed Aircraft Corp.

Jean Raeburn, N.Y.

VICE-PRESIDENT

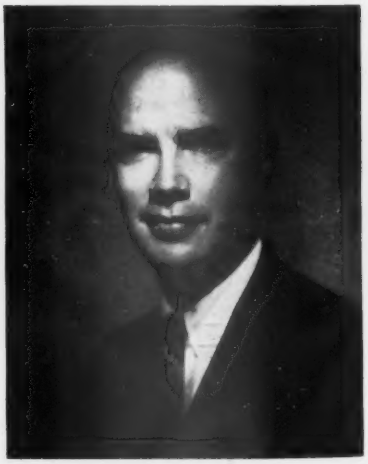
H. Guyford Stever (Left)

Prof., Aero. Engrg.
Assoc. Dean, School of Engrg.
M.I.T.

TREASURER

R. Dixon Speas

Aviation Consultant



XUM

Newly Elected Members of the

INSTITUTE COUNCIL

EASTERN AREA, 1-year term

Fred N. Dickerman

Chief Preliminary Design Engineer
Lockheed Aircraft Corporation

Ira G. Ross

Executive Vice-President & Director
Cornell Aeronautical Laboratory, Inc.

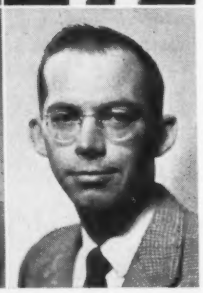
CENTRAL AREA, 1-year term

Kenneth L. Burroughs

President, Aeronautical University

George R. Gehrkens

Chief Engineer
North American Aviation, Inc.



WESTERN AREA, 1-year term

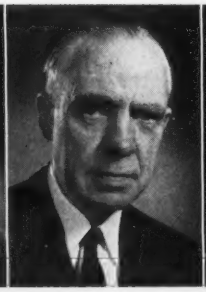
Earl Hinz

Unit Chief, Systems and Controls
Ryan Aeronautical Company

Lloyd T. Goodmanson

Project Engineer,
Boeing Airplane Company

THREE-YEAR COUNCIL MEMBERS



Preston R. Bassett
Consultant

Raymond C. Blaylock
Vice-President
Engineering
Chance Vought
Aircraft, Inc.

C. M. Bolster
Director, Development
The General Tire &
Rubber Co.

Luis de Florez
Consulting Engineer

William Littlewood
Vice-President
Equipment Research
American Airlines, Inc.

T. F. Walkowicz
Investment Advisor
Staff of
Laurance S. Rockefeller

INSTITUTE OF THE AERONAUTICAL SCIENCES, INC.

Statement for the Fiscal Year October 1, 1956, to September 30, 1957

Consolidated Balance Sheet and Operating Statement

ASSETS

Unrestricted:

Cash on Deposit	$134,819.99	
Accounts Receivable	35,936.18	
Advances on Intrafund Accounts	34,280.32	
Deposits and Prepayments	37,273.38	
Investments	527,835.78	
Furniture and Fixtures	5,000.00	
Total Unrestricted Assets		$ 775,145.65

Specific:

The Sherman M. Fairchild Fund	$ 8,102.00	
The G. M. Giannini Fund	139.47	
The Guggenheim Fund	392,841.38	
The Paul Kollsman Fund	69,000.00	
The Vernon Lynch Award Fund	37,260.93	
The Minta Martin Aeronautical Student Fund	511,460.14	
The Sylvanus Albert Reed Award Fund	13,580.40	
The Lawrence Sperry Award Fund	13,421.37	
The Water-Based Aircraft Fund	20,050.48	
The Los Angeles Building Operating Fund	9,419.99	
The Pacific Aeronautical Library Fund	29,127.82	
The San Diego Building Operating Fund	12,495.11	
Total Specific Assets		$1,116,899.09

Facilities (at Cost):

Los Angeles	$427,640.20	
New York	220,951.21	
San Diego (land leasehold)	176,706.11	
Total Facilities		$ 825,297.52

LIABILITIES AND RESERVES

Unrestricted:

Accounts Payable and Deposits	$165,202.14	
Deferred Credits to Income	118,556.62	
Deferred Income—San Diego Building	15,247.77	
Deposit—Pacific Aeronautical Library	12,000.00	
Reserves	232,110.02	
General Fund—Balance September 30, 1957	232,029.10	
Total		$ 775,145.65

Specific Funds (see Assets) $1,116,899.09

Buildings, Land, and Equipment (see Assets) ..... $ 825,297.52

Statement of Income & Expenses

Income:

Advertising Revenue	$419,680.83	
Dues and Entrance Fees	280,568.70	
Subscriptions and Related Accounts	160,000.89	
West Coast Buildings Revenue	58,671.67	
Investment (unrestricted)	33,877.25	
Miscellaneous	20,242.71	
Contracts Overhead	16,973.69	
Total Income		$990,015.74

Expenses:

Publications	$468,966.51	
Salaries—Administrative, Clerical, & Accounting	170,083.30	
West Coast Offices	97,987.45	
Libraries and Related Activity	96,075.98	
Meetings and Travel	35,655.97	
Employees Retirement Fund & Social Security	27,938.33	
Printing, Postage, Communication, and Equipment	26,446.73	
Vocational Guidance Manual	18,050.37	
Building Maintenance	17,410.72	
Office Supplies and Expense, Insurance	15,324.26	
Miscellaneous	7,513.78	
Total Expenses		$981,453.40
Net Income		$ 8,562.34

of papers presented have increased slightly; however, additional meeting personnel have been added to the New York and Los Angeles staffs which increases payroll costs. Section meeting costs, even with the yeoman service of the local Officers and Committees, have increased 6 per cent this year.

During the year, gross advertising revenues from the AERONAUTICAL ENGINEERING REVIEW increased approximately 8 per cent over the prior year; however, the publishing and editorial costs went up also, with the result that the net income from this source was $15,500 less than in 1956.

The AERONAUTICAL ENGINEERING CATALOG dropped 6 per cent with the net income down $2,700.

An extraordinary cost of $18,000 was approved by the Council this year for the production and distribution of a pamphlet entitled *Your Career as an Engineer in Aviation*. One hundred and twenty-five thousand copies of this publication, intended to interest American youth in the aeronautical engineering profession, were distributed, reaching every state in the Union.

Library costs increased 9 per cent over 1956 mainly because of additional personnel required, expanded reference service, and maintenance of an ever-increasing number of acquisitions.

The Institute's Film Catalog contract with the ARDC which was extended for 1 year from July 1, 1957, was terminated in September for the convenience of the Government. This termination was rescinded on January 6, 1958. At the request of the AFOSR, the joint participation cost contract in producing the International Aeronautical Abstracts was expanded to provide French and German language editions for distribution overseas. In both contracts, the overhead recovered aids in the balancing of our budget.

The West Coast operations consisting of the Los Angeles and San Diego Buildings, together with the Pacific Aeronautical Library, were maintained on the same general basis as during the preceding year. Additional building improvements in Los Angeles, together with increasing janitorial and maintenance salaries, resulted in a deficit operation of $2,000; the San Diego Building costs were also $2,000 more than income. A higher payroll, together with increased costs in producing the Uniterm Index, resulted in a slight deficit in the operations of the Pacific Aeronautical Library.

Long-range studies have been made to consider maintenance of essential IAS services under reduced income conditions. The 1957–1958 Budget, predicated on current conditions in the aircraft industry and generally representing a 10 per cent reduction in overall income, has been approved by the Council.

The books of the IAS were audited by Harris, Kerr, Forster & Company. A copy of their complete report is available to members at the national office.

PRESTON R. BASSETT
Treasurer

Director's Report—1957

NINETEEN fifty-seven will go down in history as that year in which man's first penetration of outer space touched off a great resurgence of interest in science and technology. Science and scientists have suddenly become respectable. Research and development are no longer nasty words around Washington. The inadequacies of United States scientific educational programs have been starkly silhouetted against the glare of Russian rockets.

To most members of the Institute of the Aeronautical Sciences, many of these things have come as no surprise. The shape of things which have now come has been discernible in our activities for many years. The people who have brought these things to fruition are, for the most part, members of this organization. Our meetings and our publications have kept ahead of the trends of thinking restricted only by the limits imposed by security regulations. For most of us it has not been a question of "*What* will happen?" but only "*When* will it happen?"

In the field of scientific education we have long been aware of our deficiencies and have done what we could to repair them. Through the publication of vocational guidance manuals, of compendiums of the industry's scientific educational programs, and through the establishment of educational advisory committees, we have made substantial contribution in this area during the past year.

The spectacular upsurge of interest in space travel has had a marked effect on our own activities. We are not overlooking the fact that active development of conventional forms of aircraft is highly important and will continue to be so for the indefinite future. Our current programs, however, reflect the rising interest in travel outside the normal boundaries of the earth's atmosphere.

This shift in emphasis has also had negative effects on our policies and activities.

The glamorous aspects of space flight have fostered formation of many new "splinter" societies which have seized the opportunity to promote their special fields of interest on a vertical pattern. As a corollary, a rash of new "technical" publications has broken out, each one striving to pay its own way by the sale of advertising pages to the aircraft, missile, and components industry. This has already had a noticeable effect on our income from the sale of advertising in the Institute's REVIEW and CATALOG. We have been forced to cut content somewhat and to effect certain other economies. This condition, coupled with the uncertain financial outlook in industry during the last 2 or 3 months of 1957, has caused us to re-examine our overall budgets and to make plans to meet what (we hope) is a temporary shrinkage in income.

As will be noted from the Treasurer's report, however, we wound up our fiscal year in the black. Looking ahead into 1958, our budgets have been drawn up to take account of the shrinking income from publications, but, with the assistance that has been forthcoming from the increase in Corporate Member dues authorized by the Council last year, we expect to break even on the current year's operations.

As has been stated recently in editorials in the REVIEW, the Institute is pursuing what we believe to be a conservative, middle-of-the-road course. We believe that we have a continuing obligation to the present aircraft industry, as well as to future proponents of space travel. We have stated our belief that the Aeronautical Sciences are concerned with "any vehicle that leaves the surface of the earth and goes anywhere, by whatever means." We have also stated our policy to "continue to serve

TABLE 1
Membership Report, December 31, 1957

	12/31/55	*12/31/56*	*12/31/57*
Temporary Honorary Members	16	15	16
Honorary Fellows	32	30	32
Fellows	198	202	213
Associate Fellows	926	1,041	1,240
MEMBERS	4,668	5,284	5,778
Associate Members	502	546	...
Associates	4,633	4,981	6,074
Total Graded	10,975	12,099	13,353
Student Members	2,984	3,908	4,274
Total	13,959	16,007	17,627

TABLE 2
Sections and Branches, December 31, 1957

	1947	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*	*1954*	*1955*	*1956*	*1957*
Sections	17	19	19	23	24	25	26	24	27	27	28
Meetings	92	121	126	144	168	181	237	241	267	275	320
Members	4,734	5,032	5,718	6,436	7,143	7,379	8,408	8,411	9,043	9,837	11,120
Branches	51	60	67	70	71	71	69	71	73	74	73
Meetings	277	327	336	317	323	350	319	366	227	313	319
Members	3,300	4,068	3,958	3,395	3,006	2,796	2,672	3,110	2,984	3,908	4,274

the interests of our members at all altitudes from Zero to Infinity."

Membership

The real test of success in an organization of this character is the trend of its membership. People simply will not join or will drop out if the programs are not to their liking.

Again, without recourse to national campaigns, the Institute has experienced another year of steady growth to a new high in all categories. Never before have more applications come in, both for new membership and for regrading. Losses were relatively low. Both the gross and the net increases are the largest in our history. Tables 1 and 2 tell the story. We are approaching the 18,000 mark in total membership.

Sections

For the twelfth consecutive year, all aspects of Section operation reached new highs. Section membership increased by over 1,200 in 1957. This continues to represent over 80 per cent of total IAS membership. The number of Section meetings increased from 275 to 320 in the past year.

A new Section was organized in Kansas City, increasing the total to 28. Negotiations are under way for the establishment of Sections in central Florida, Miami, Redstone Arsenal, and Birmingham. Two subsections, in Antelope Valley and Daingerfield, became operative in 1957. It is believed that Antelope Valley should have full Section status immediately.

Four issues of the Section Chairmen's *Newsletter* were published in 1957: February 26, May 15, October 18, and December 11. Two meetings of Section Chairmen were held, one in New York during the Annual Meeting in January and one in Los Angeles during the Summer Meeting in June. The *Guide for Section Officers* was again revised, and the improved version is in the hands of each officeholder.

All Sections have Student Activities Committees or their equivalent and are rendering student aid in areas ranging from career clinics to television programs. It is significant that seven IAS Sections put on television shows in 1957.

The Second Minta Martin Lecture was presented in 1957 at meetings involving the Boston, Washington-Baltimore-Hagerstown, Los Angeles, St. Louis, Seattle, and San Francisco Sections.

In 1957 the Sections continued to be the prime movers of IAS student literature and the sponsors of our regional student activities.

Student Activities

Present student membership enrollment in 73 branches is 4,274, a new high. During 1957 S-A transfers were offered to 1,468 graduated student members; 747 accepted, a return of 51 per cent.

Nine monthly editions of the *Student Branch Newsletter* were published and distributed. Copies of the Director's article "Institute of the Aeronautical Sciences," reprinted from the *General Electric Review*, were distributed to all Student Members. Student Members also received copies of the Director's editorial "Zero to Infinity," reprinted from the December, 1957, REVIEW.

In the spring of 1957, eight Regional Student Conferences were held, one each in Detroit, St. Louis, Fort Worth, Atlanta, Los Angeles, Indianapolis, Princeton, and Charlottesville, W.Va. Twelve technical papers which won first prizes in the 1957 Conferences were published in the *1957 First Award Papers;* 750 copies have been distributed to Sections, Branches, Corporate Members, schools, libraries, and interested individuals.

Two National Awards (1956)—one graduate, one undergraduate—were presented in 1957. The two 1957 winners who have been selected will receive engraved plaques early in 1958. Duplicate National Awards were presented to the schools of the National winners.

A script was written, taped, and delivered to the Atlanta Section for their film descriptive of the 1957 Southeastern Regional Student Conference, scheduled for release early in 1958.

A revised edition, 28 pages, of the *Giannini Film List* was published in February, 1957; 1,000 copies have been distributed. In September, 1957, a 3-page *Supplement* to the February, 1957, edition was published and distributed. A folder, descriptive of the Giannini Film Library, was also printed in 1957 and has been useful in encouraging donors to provide film prints for the Library; 820 film loan requests were handled, 432 serviced in 1957.

Meetings

At the national level, we either organized or participated in some 16 major meeting operations during the year, as follows:

National Meetings—1957

Jan. 28–31	IAS Twenty-Fifth Annual Meeting, New York
Jan. 31–Feb. 1	Participation in Symposium on Digital Computing in the Aircraft Industry, New York
Mar. 11–15	Participation in EJC Second Nuclear Engineering & Science Conference of the 1957 Nuclear Congress, Philadelphia
Mar. 14–15	IAS Flight Propulsion Meeting (Confidential), Cleveland
Apr. 14–16	Participation in IRE National Symposium on Telemetering, Philadelphia
May 13–15	Participation in IRE National Aeronautic Electronics Meeting, Dayton
May 27–29	IAS-ISA-AIEE National Telemetering Conference, El Paso
June 17–20	IAS Summer Meeting, Los Angeles
June 20	IAS Field Trip, Palmdale Flight Test Center, California
June 19–20	IAS-Stanford University Heat Transfer and Fluid Mechanics Institute, Stanford University, Stanford, Calif.
Aug. 5–10	IAS Naval Aviation Meeting, San Diego
Aug. 7	IAS Carrier Field Trip, U.S.S. "Ticonderoga"
Sept. 1–15	RAeS-IAS Sixth International Conference, London and Folkestone, Eng.
Oct. 21–22	CAI-IAS Joint Meeting, Montreal, Can.

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Nov. 7–8	IAS Midwestern Meeting on Weapons System Management, Dallas
Dec. 17	IAS Twenty-First Wright Brothers Lecture, Washington, D.C.

Preparation and handling of meetings of such calibre and frequency impose a heavy load on our relatively small staff. Such a program would not be possible without the help and support of the IAS Sections on the spot. Particular mention should be made of the effort put on these meetings by the Cleveland, Los Angeles, San Diego, and Texas Sections.

In addition to the national effort, our 28 sections have been building up the quality of their programs at a very gratifying rate. Careful program planning by all Section officers has resulted in great improvement in all areas and is directly responsible for the membership growth reported above. We believe that the real strength of the Institute is at the Section level, and the objective of the national organization is to support Section activities to the best of our capability.

The same may be said for our Student Branches. A great improvement has been shown in practically all areas, both in quantity and in quality. This stems to a great degree from the interest that has been taken by our Sections in the welfare of the Student Branches in their areas. Constant support is being given to the student groups from headquarters (in the form of newsletters, film lists, thesis suggestions, regional prizes, etc.), but there is nothing more stimulating to student organizations than direct interest and assistance from senior IAS members in the Sections, and judging from results they are evidently doing a fine job in this direction.

The Regional Conferences, mentioned above, have become an extremely important part of the Institute's meetings program.

Publications

Throughout the year, the JOURNAL maintained a high level of content quality under the editorship of Dr. William Sears of Cornell. Approximately 80 pages per issue were published. The "Readers' Forum" continues to grow in both size and importance.

A complete restudy of the editorial content of the REVIEW was undertaken early in the year, based on surveys and comments from our membership. The shifting areas of interest of readers are being watched closely, and constant effort is being put on meeting their requirements. Of interest is the fact that more and more original articles are appearing in the REVIEW. A few years ago, our own meetings were the principal sources for REVIEW papers. Now, as a result of continuing search for new material from Government and industry research, development, and design sources, almost half of the feature articles of 1957 were original contributions. Shorter, more condensed treatment of essential information for the use of engineers is the objective.

The dollar volume of advertising sold during fiscal 1957 was the largest in the history of the REVIEW. However, the calendar year wound up showing a slight decrease in total revenue over calendar 1956. This was brought about by the sudden drop-off in advertising in the last 3 months of the year immediately following the Government's announced cutbacks for the industry in the late summer.

All magazines in the field were similarly affected. From the point of view of percentage, the REVIEW's cutbacks amounted to less than those felt by most of the other publications. It was necessary, however, to initiate steps that would bring the publication costs of the magazine into closer balance with the anticipated revenue without curtailing the value and usefulness of its services to Institute members. This is being accomplished through a slight increase in advertising page rates, increased subscription rates to nonmember subscribers, and certain editorial and format changes which reduce printing and production costs.

It is anticipated that advertising revenues will again show an upward trend by midyear. Meanwhile we are continuing a vigorous advertising sales and promotion effort and keeping a weather-eye on the market trends.

The AERONAUTICAL ENGINEERING CATALOG was published early in 1957. This edition was in the format that was found satisfactory in 1956. The 1957 edition produced a small margin of increase over expense.

Pacific Aeronautical Library

The Pacific Aeronautical Library has received many new requests for library service during the past year, with the result that it now serves more than 50 individual organizations, some with as many as eight separate plants.

This growth is reflected in the circulation statistics. During 1957 the Library circulated 42,938 items as compared with the 38,851 items for 1956. These figures included 1,780 items circulated to individual Institute members not belonging to our subscribing plants. They also include 7,147 items borrowed through interlibrary loan as against only 5,983 items borrowed during 1956. The Library has been fortunate to have this material made available to it on loan and tries to keep these privileges by returning material promptly and making its services available to the faculty and students of the lending universities. Partly to expedite return of this borrowed material and partly to serve more quickly the outlying plants, the Library has recently started using United Parcel Service instead of relying entirely on our messenger and the mail.

New material processed within the Library has shown an increase during the past year. There have been 10,291 new items cataloged, an increase of 3,296 over 1956.

The Library's *Uniterm Index to Periodicals* had covered 21,643 articles by the end of 1957 and continues to be issued with quarterly cumulations. This system has evinced interest in places as far apart as Iceland and Australia, the U.S.S.R. and Argentina; and the hope has been expressed that there could be one cumulated volume covering the indexing of earlier years.

New York Library

During 1957, the upward trend in the activities of the Library at the IAS National Headquarters was maintained. The Library's services continued to grow in response to the increased demands of the IAS membership and the aeronautical community as a whole. Efforts to keep up with the quantity of published scientific and technical information were intensified and resulted in a high rate of acquisition of published materials and in a further growth in the number of abstracts published in the AERONAUTICAL ENGINEERING REVIEW. In connection with abstracting, increased emphasis was given to reporting work published outside the Western Hemisphere, including the Soviet Union.

A total of 6,770 items (periodical articles, so-called technical reports, conference papers) were covered during 1957 in the *International Aeronautical Abstracts* and *Aeronautical Reviews* sections. In the January and February, 1958, issues, 1,140 items have been covered. The Soviet Union and its European satellites are represented as follows:

	Jan.–Dec., 1957	*Jan.–Feb., 1958*
Soviet Union	368	171
Poland	100	10
Rumania	74	4
	542	185
Articles from Soviet periodicals in "cover-to-cover" translation	72	9
	614	194

With respect to acquisition of periodicals, the number of titles received from all countries stands at 545. The

Soviet Union and other Communist countries figure in this total as follows:

Soviet Union	15
Rumania	10
Poland	9
Hungary	3
China (Mainland)	2
Yugoslavia	1
Cover-to-cover English translation from the Russian	4
English-language periodicals indexing Soviet literature or translations of it	3

Circulation of periodicals, reports, books, and papers showed a rise of 31 per cent over 1956 (48 per cent when compared with 1955). The publications loaned helped to serve principally the needs of Corporate and Individual Members of the IAS. Various U.S. Governmental research and development agencies and university contractors to the Department of Defense were also served. The interest of IAS members in foreign developments may be shown by the fact that approximately 40 per cent of the publications circulated originated outside the United States. *Photocopying* continued to be an important service to those desiring retention copies of needed articles and reports.

Acquisition work through the year has maintained the large input of needed publications. Periodicals received particular attention. More than 500 titles, of all types, are now received, as follows: North and South America, 332; Western Europe, 147; Eastern Europe (including the Soviet Union), 37; Far East, 26; Near East, 2; and Africa, 1. Coverage of periodicals from Communist countries, either in the original languages or in translation, is approaching 10 per cent of the total number of titles received.

Periodical articles and reports covered in the *International Aeronautical Abstracts* and *Aeronautical Reviews* sections of the AERONAUTICAL ENGINEERING REVIEW totaled 6,759 in 1957 (a gain of 43 per cent over 1956); 1,017 of these were from foreign-language originals (15 per cent of the total). The twelve monthly issues of *International Aeronautical Abstracts*, which is prepared with the support of the U.S. Air Force Office of Scientific Research, were also translated by the IAS staff into the French and German languages. These foreign editions, which were supported by the U.S. Air Force Office of Scientific Research, were published by the IAS and distributed in Europe by the European Office of the Air Research and Development Command of the U.S. Air Force. Each of these editions required the translation of approximately 93,600 words (187,200 total). Two hundred ninety-eight volumes were annotated in the *Books* section of the REVIEW.

Cataloging was kept up to date, while inroads were made into some remaining backlog of uncataloged material. Special card catalogs were also maintained for reference use.

All in all, approximately 10,000 inquiries were handled by the Library staff, either by mail, telephone, or personal visit. The Historical Collections were further consolidated and classified, particularly in the area of photographs. The Historical Collections continued to service requests from staff, members, and organizations in the area engaged in aeronautical activities.

International

During 1957 plans for the formation of an International Council of the Aeronautical Sciences came to a head. At a meeting in New York in January, representatives of ten countries met and formed a provisional organization. In Paris in May, in London in September, and in Washington in November, specific programs were developed for a First International Congress to be held in Madrid, Spain, in September, 1958.

The Institute has been playing an active part in these plans and is established as the Permanent Secretariat for ICAS. With the authorization of the IAS Council, the income from the fund derived from the sale of the Guggenheim Estate at Sands Point (Long Island) to the U.S. Navy has been made available for the support of the work of the International Council.

Throughout the years the IAS has continued its close collaboration with AGARD both through its established Panel activities and in connection with its General Assembly in Washington in November.

The Sixth Anglo-American Conference was held in London and Folkestone, England, in September, 1957. Approximately 100 Americans (some accompanied by wives and children) attended. Some 500 delegates were present. By joint action of the Councils of the RAeS and the IAS, plans have been made for a Seventh Conference to be held in the Northeastern section of the United States in October, 1959.

Collaboration with the Canadian Aeronautical Institute continued in the form of joint meetings and financial support. By the end of the year, however, the CAI Council advised us that, inasmuch as the society was not firmly established, its local financial support was ample for its needs and no additional grants from the IAS or the RAeS would be needed in the future.

Facilities

A continuous maintenance and modernization program in all buildings has been continued throughout the year. Our physical plant is in good repair and is under constant inspection.

Activity in the Los Angeles building continues at a high level. Budget balancing is an ever-present problem, but the Building Management Committee and our Western Region Manager are exploring every avenue whereby revenues can be increased by greater building utilization.

During the past year a temporary solution was reached for the San Diego facility. An agreement has been reached and a $5^1/_2$-year lease signed with California Western University whereby the latter takes over the entire responsibility for the building at a satisfactory rental, while we retain use of the building for our local meetings, etc., on a prescheduled basis. Any funds accumulating under this agreement will be earmarked for the future use of the IAS San Diego Section. It is felt that this is an extremely satisfactory method of handling what has been a difficult problem. E. T. Price, formerly of Solar Aircraft and a past member of our Council, was responsible for the initial suggestion and was extremely helpful during the negotiations.

General

During the course of the year the New York staff visited a large number of our Sections and Branches. Our travel schedules have been heavy, with increasing meetings commitments in this country and overseas.

With expanding membership and worldwide interests, the demands on the staff have been steadily rising. At the same time, budget restrictions have limited the number of people we can put on various projects. We are indeed fortunate in having a staff of hard working, dedicated people who carry on the business of this organization. We give them full credit for making the Institute what it is today—one of the outstanding scientific societies of the world.

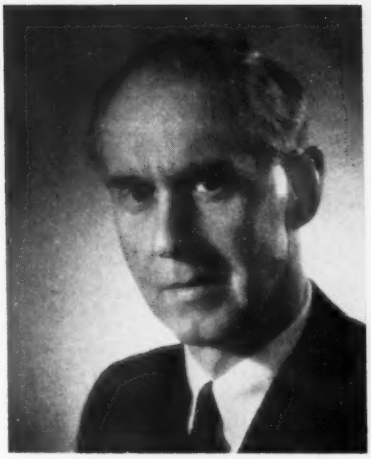
S. PAUL JOHNSTON
Director

✦ ✦ ✦

AMERICAN HONORARY FELLOW
William Littlewood

Honorary Fellows for 1957

Honorary Fellows shall be persons of eminence in aeronautics and are elected by the Fellows and Honorary Fellows of the Institute residing in the United States. Not more than one person residing in the United States, nor more than one person residing in a foreign country may be elected as Honorary Fellow in any one year.



FOREIGN HONORARY FELLOW
Bo K. O. Lundberg

Fellowship in the Institute—1957

Fellows of the Institute of the Aeronautical Sciences shall be those who have attained a position of distinction in aeronautics and made notable and valuable contributions in one of the aeronautical sciences or aeronautical engineering.

- **Raymond C. Blaylock**
  Vice-President, Engineering
  Chance Vought Aircraft, Inc.
- **Adolf Busemann**
  Staff Scientist
  Langley Aeronautical Lab., NACA

- **Milton U. Clauser**
  Director, Aeronautical Research Lab.
  The Ramo-Wooldridge Corp.
- **Lt. Gen. Laurence C. Craigie, USAF (Ret.)**
  Vice-President, American Machine & Foundry Co.
- **Luigi Crocco**
  Goddard Professor of Jet Propulsion
  Princeton University

- **Brig. Gen. Marvin C. Demler, USAF**
  Deputy Commander
  Research & Development, ARDC
- **I. E. Garrick**
  Chief, Dynamic Loads Div.
  Langley Aeronautical Lab., NACA

- **Roy E. Marquardt**
  President,
  Marquardt Aircraft Co.
- **Raymond C. Sebold**
  Vice-President, Engineering
  Convair Div., General Dynamics Corp.
- **Hartley A. Soule**
  Assistant Director
  Langley Aeronautical Lab., NACA

IAS Awards for 1957

Major David G. Simons, USAF
Chief, Space Biology Branch
Aero Medical Field Laboratory, Holloman AFB

The John Jeffries Award

This award honors the memory of Dr. John Jeffries, an American who, with Blanchard, the French balloonist, made the first aerial voyage across the English Channel in 1785 and one a previous flight made the earliest recorded scientific observation from the air. The award was established by the IAS in 1940 to give recognition to the importance to aviation of scientific endeavor in the field of medicine.

Presented to DAVID G. SIMONS

"For his valuable pioneering contributions which establish beyond question the feasibility of human survival and effectiveness at extreme altitudes."

Major David G. Simons, Chief, Space Biology Branch, Aero Medical Field Laboratory, Holloman AFB Air Development Center, has distinguished himself by the exceptional achievement of performing a record-breaking solo flight to an altitude of 102,000 ft. This was accomplished in a gondola suspended from a plastic balloon on August 19 and 20, 1957 He was aloft for 32 hours, 26 of which were at altitudes equivalent to space.

Major Simons made scientific measurements constituting a valuable pioneering contribution to our knowledge of extreme altitude flight and having international significance.

Despite obstacles experienced during the launch (he was in the gondola $10^1/_2$ hours prior to flight), he remained stable and effective throughout the entire period of confinement. Also, he submitted to many months of preparatory training during which he participated in parachute jumps, altitude chamber tests, and free balloon flights. These hazardous activities were additional to the duties of planning and executing the entire project. He received the Distinguished Flying Cross for his heroic feat.

Major Simons was born on June 7, 1922, in Lancaster, Pa. He received a B.S. in Chemistry from Franklin and Marshall College in 1943 and his M.D. degree from Jefferson Medical College in 1946. He entered military service in 1942 and in 1947 began a study of weightlessness problems at Wright-Patterson AFB.

Jule G. Charney
Professor, Meteorology
Massachusetts Institute of Technology

The Robert M. Losey Award

Established in 1940, this annual award honors the memory of Capt. Robert Moffat Losey, a member of the Institute and a meteorologic officer of the Air Corps, who was killed at Dombas, Norway, April 21, 1940, while serving as an official observer for the U.S. Army. He was the first officer in the service of the United States to die in World War II. The award carries an honorarium.

Presented to JULE G. CHARNEY

"In recognition of outstanding contributions to the science of meteorology as applied to aeronautics."

Jule G. Charney, Professor of Meteorology, Department of Meteorology, M.I.T., has been working in what may be called "planetary field dynamics"—the study of the large-scale circulation of the atmosphere and the oceans by analytical and high-speed computational methods. Techniques that he and his colleagues developed for numerical weather prediction were by-products of this study.

Dr. Charney is credited with the procedure filtering which opened the door to this new approach to weather forecasting. The resulting studies promise more accurate high-level wind forecasts which are necessary for jet operations. To this end, a Joint Numerical Weather Prediction unit has recently been set up in Washington, D.C.

Dr. Charney earned his B.A., M.A., and Ph.D. at the University of California, at Los Angeles. While a University Fellow in Mathematics, he was made an instructor in the wartime meteorological training program, which gave birth to his interest in theoretical meteorology.

He was awarded a National Research Fellowship which, after 1 year as Research Associate in Meteorology at the University of Chicago, he used for further studies at the Aerophysical Institute, Oslo, Norway.

He was Director of a meteorology project at the Institute for Advanced Study before joining the M.I.T. staff in 1956.

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Raymond L. Bisplinghoff
Professor, Aeronautical Engineering
Massachusetts Institute of Technology

The Sylvanus Albert Reed Award

The late Dr. S. A. Reed, designer of metal aircraft propellers and a Founder Member of the IAS, made an endowment to the Institute in 1933 to provide an annual award to be presented for a notable contribution to the aeronautical sciences, resulting from experimental or theoretical investigations which have had a beneficial influence on the development of practical aeronautics. The award consists of a certificate and an honorarium. The recipient is chosen by ballot of the American Honorary Fellows and Fellows of the Institute.

Presented to RAYMOND L. BISPLINGHOFF

"For developing and systematizing techniques for calculating dynamic loads and stresses in aircraft structures making practicable accurate routine prediction of transient response during maneuvers."

Raymond L. Bisplinghoff, Professor, Aeronautical Engineering, M.I.T., directed, together with H. Guyford Stever, a 3-year research program to predict the stresses in aircraft structures due to atomic bomb blasts. This involved participation in tests at Eniwetok in the spring of 1951, for which he received a certificate of achievement from the Air Force.

Professor Bisplinghoff was codesigner and builder with Hans P. Liepman of the University of Cincinnati wind tunnel (1942), and with M. A. Biot developed a theory of predicting dynamic stresses in aircraft structures used by the aircraft industry during the latter part of the war. He developed a seaplane impact theory and supervised a research program to extend and corroborate it. From this work he wrote the Navy seaplane load requirements which were later adopted by the ICAO.

He has been responsible for graduate courses in dynamics of aircraft structures offered to M.I.T. students since 1946, and with staff members and thesis students developed methods of dynamic stress analysis for gusts, landing loads, gun blast, swept-back wings, and wings with cutouts.

Other achievements by Professor Bisplinghoff include theory and design of a sandwich-type mounting system for the Allison V-1710 engine and coauthorship of the book *Aeroelasticity*.

Clarence A. Syvertson
High Speed Research Division
Ames Aeronautical Laboratory, NACA

The Lawrence Sperry Award

This award was endowed in 1936 by the sister and brothers of the late Lawrence Burst Sperry, pioneer aviator and inventor, who was drowned in 1923 at the age of 31 after a forced landing in the English Channel. The certificate and honorarium are presented annually for a notable contribution made by a young man to the advancement of aeronautics.

Presented to CLARENCE A. SYVERTSON

"For significant contributions to the solution of the problem of flight at hypersonic speeds with particular reference to the fundamental understanding of hypersonic airflow and its application to efficient aircraft design."

In the broad research attack upon the many problems of hypersonic flight, Mr. Syvertson's energies and abilities have produced numerous substantial achievements fundamental to progress. He is Assistant Chief, 10- × 14-in. Supersonic Wind Tunnel Branch, High Speed Research Division, Ames Aeronautical Laboratory, NACA.

He has improved the understanding of hypersonic aerodynamics and played an important role in evolving aircraft configurations for efficient hypersonic flight.

Mr. Syvertson also has established practical design principles for building research tools needed to study high-speed aerodynamics using an approach through analysis and experiment that has resulted in notably simple and practical methods for designers in industry, as well as for research.

As a logical extension of his fundamental work, he is currently studying ways to combine wings and bodies for attaining maximum aerodynamic efficiency at hypersonic speeds.

A native of Minneapolis, Minn., Mr. Syvertson graduated in 1946 from the University of Minnesota with the degree of Bachelor of Aeronautical Engineering. After serving in the Army, he returned to this school where he received an M.S. degree in 1948. He joined the staff of Ames Aeronautical Laboratory in 1948 as an Aeronautical Research Scientist and is currently completing work required for a Ph.D. degree at Stanford University.

Awards, continued

Herman Mark

Samuel J. Harris, III

IAS Minta Martin National Student Awards

The Minta Martin Aeronautical Student Fund was established by the late Glenn L. Martin in honor of his mother who encouraged him in his aviation pursuits. It is administered by the IAS to encourage aeronautical engineering education. This is accomplished in part through several annual regional student conferences where students have the opportunity to present original technical papers in competition for cash awards. From the first prize graduate and undergraduate papers, two national award winners are chosen by a board of professional scientists and engineers. They receive plaques engraved for outstanding engineering achievement, duplicates of which go to the winners' universities.

Presented to

HERMAN MARK: Graduate Division

SAMUEL J. HARRIS, III: Undergraduate Division

This year's Graduate Division winner, Herman Mark, is currently an Aeronautical Research Engineer at Lewis Flight Propulsion Laboratory, NACA. He won the award for a paper on "The Interaction of the Reflected Shock Wave with the After-Flow Boundary Layer."

Mr. Mark received a Bachelor's degree in Mechanical Engineering from the College of the City of New York in 1944 and after military service, in which he was assigned to the NACA, received an M.S. degree from Case Institute of Technology. He received his Ph.D. from Cornell University last June.

Samuel J. Harris, III, the Undergraduate Division winner, is an Associate Engineer, Missile Aerodynamics, Douglas Aircraft Company, Inc., Santa Monica. The paper that won him the National Award, "Determination of Pressure Drag on Bodies of Revolution in Transient Flight," also won first prize in the IAS 1957 Northeastern Regional Conference. Mr. Harris also took third place with another paper in the 1957 Southeastern Regional Conference.

A native of Danville, Va., he was graduated from Virginia Polytechnic Institute last June.

The awards were presented at the Twenty-Sixth Annual Meeting to Mr. Mark, to Cornell, and to V.P.I. Mr. Harris will receive his award on the West Coast.

The Grover E. Bell Award

The late Lawrence D. Bell created this award in his will as a memorial to his brother who died in an aircraft accident in California in 1913. The award, consisting of a medal, certificate, and honorarium, is administered by the Buffalo Foundation for the purpose of fostering and encouraging research and experimentation in the field of helicopter development.

Presented to KURT H. HOHENEMSER

"For outstanding achievement in solving the complex dynamics problem required in the development of the world's first successful convertiplane, the McDonnell XV-1."

Dr. Hohenemser, Chief Aeromechanics Engineer, Helicopter Division, McDonnell Aircraft Corporation, has made major contributions to his firm's Convertiplane.

An Honorary Fellow of the American Helicopter Society and an IAS Associate Fellow, he has published some 35 technical articles in three areas—theory of vibrations, theory of elasticity and plasticity, and theory of helicopter flight.

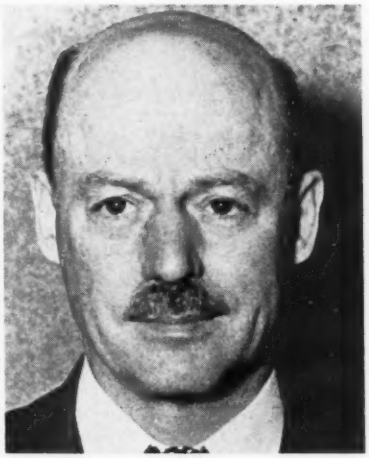
He was responsible for the autogyros and helicopters developed by A. Flettner Aircraft Company, Berlin, Germany, from 1935 to 1945. From 1930 to 1933, Dr. Hohenemser was a Research Fellow under Ludwig Prandtl, working in structural dynamics, plasticity, and fatigue of metals at the University of Gottingen. He also was a Lecturer in Applied Mathematics and Mechanics there.

He was the aerodynamicist for the four-seat travel plane produced by G. Fieseler Aircraft Company (Germany) for the European competition of 1934.

Kurt H. Hohenemser
Chief Aeromechanics Engineer
Helicopter Div., McDonnell Aircraft Corp.

The Bell Award was presented to Dr. Hohenemser by Leston Faneuf, President, Bell Aircraft Corporation.

Presentation is sponsored by one of three societies—the IAS, AHS, or AIA—in rotation.



Jerome C. Hunsaker
Professor Emeritus
Massachusetts Institute of Technology

The RAeS Gold Medal for 1957

Presented to JEROME C. HUNSAKER

The Royal Aeronautical Society announced during the Sixth Anglo-American Conference in September that Jerome C. Hunsaker, first IAS President, had been named to receive its highest honor—the RAeS Gold Medal.

The Institute's British predecessor cited Professor Hunsaker "for his contributions to aeronautical research and education, including his inspired chairmanship of the NACA."

Professor Hunsaker, now Professor Emeritus, Massachusetts Institute of Technology, was the NACA Chairman from 1941 to 1956. He was instrumental in the founding of the first course in aeronautics in the United States at M.I.T. and was Professor of Aeronautical Engineering there until his retirement in 1952.

A native of Iowa and a U.S. Naval Academy graduate (1908), he was in charge of the Aircraft Division, Bureau of Construction and Repair, during World War I. He worked on Navy-Curtiss flying boats, designed the Shenandoah, and participated in the development of the first aircraft carriers, their catapults, and arresting gear.

His many honors include the NACA Distinguished Service Medal, Navy Cross, Daniel Guggenheim Medal, Franklin Medal, Legion d'Honneur, and the Wright Brothers Memorial Trophy. He gave the eighth Wright Brothers Memorial Lecture in 1920 and is a Founder Member of the IAS.

The first Gold Medal was presented to the Wright brothers in 1909. Only 18 Gold Medals had been awarded by the RAeS up to the time Professor Hunsaker was selected. He joins a select rank of the most famous men in aviation including Octave Chanute, Ludwig Prandtl, Juan de la Cierva, Sir B. Melvill Jones, Sir Geoffrey de Havilland, and Theodore von Kármán.

The presentation was made by Sir George Edwards, 1957 RAeS President, who came to the U.S. for the occasion.

Arthur E. Raymond
Vice-President, Engineering
Douglas Aircraft Company, Inc.

The Daniel Guggenheim Medal for 1957

Presented to ARTHUR E. RAYMOND

Arthur E. Raymond—an IAS Honorary Fellow and 1946 Past President—is Vice-President, Engineering, Douglas Aircraft Company, Inc. He receives this distinguished honor "for development of a long line of successful civil and military aircraft and for notable contributions to aeronautics in public service."

Mr. Raymond has worked on practically every Douglas airplane since 1925 when he joined the firm. He delivered the second Dr. Albert Plesman Memorial Lecture (honoring the late founder of KLM Royal Dutch Airlines) at Delft, Holland, in September.

Mr. Raymond is a member of the National Advisory Committee for Aeronautics and the National Academy of Sciences.

The Guggenheim Medal is given annually by The Daniel Guggenheim Medal Fund, Inc., to honor persons who make notable achievements in the advancement of aeronautics. Presentation is sponsored by one of three societies—the IAS, ASME, or SAE.

Created in 1928 as an international award, the medal also commemorates the support given by Daniel Guggenheim to the advancement of aeronautics through donations for the support of schools of aeronautics and for the encouragement of civil aviation.

An international Board of Award was created in 1938, solely for the selection of a medalist each year. Orville Wright was recipient of the first medal in 1929. The medalists who followed, the most renowned figures in aviation, include Ludwig Prandtl, Juan de la Cierva, William E. Boeing, William F. Durand, James H. Doolittle, Lester D. Gardner, Igor I. Sikorsky, Sir Geoffrey de Havilland, and Charles A. Lindbergh.

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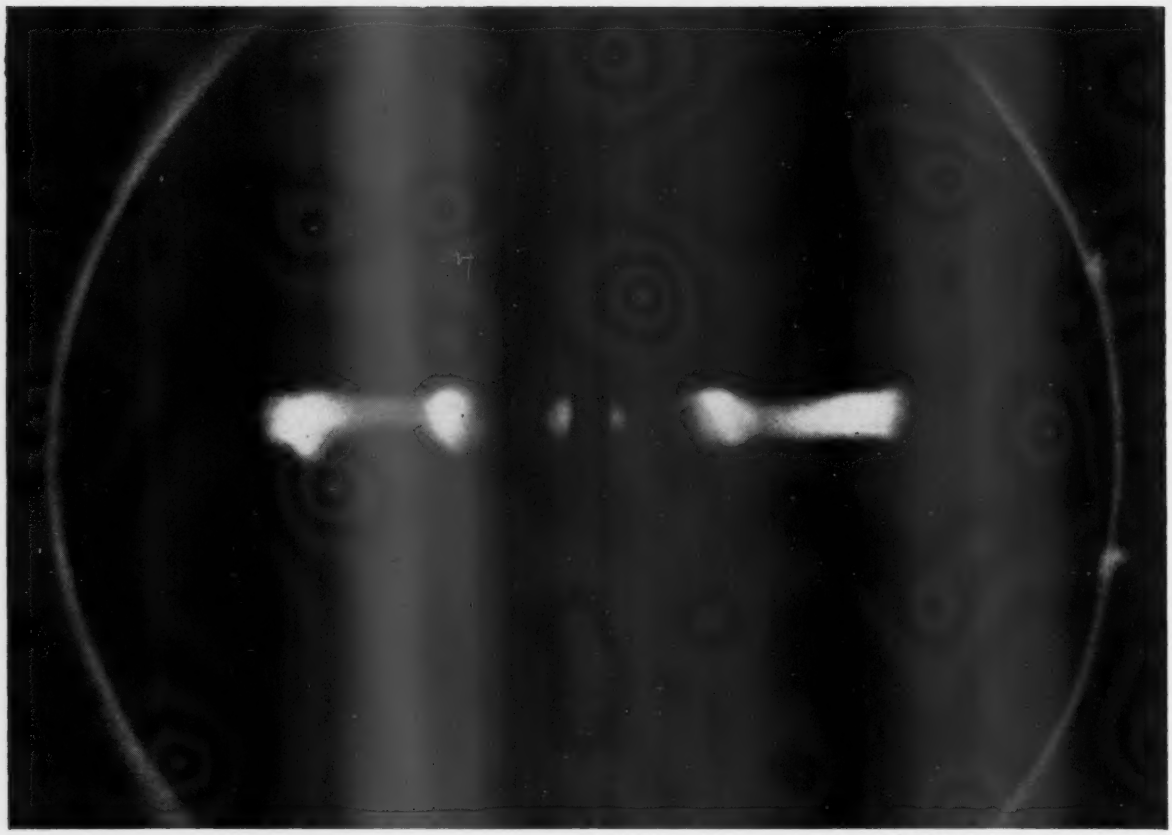

Magnetic fields, acting as a double piston, drive luminous ionized shock waves through transparent tube. One-tenth microsecond exposure in STL's Physical Research Laboratory.

MAGNETOHYDRODYNAMICS and SPACE TECHNOLOGY

Magnetohydrodynamics provides one of the most promising approaches for attaining the velocities and specific impulses that will be required for manned space flight to a planet, landing, and returning.

The critical problem in attaining velocities of hundreds of thousands of miles per hour is the containment of temperatures comparable to those in the interior of stars. Because the temperature of the driving reaction will have to rise as the square of the exhaust velocity, temperatures greater than one million degrees will be encountered in reaction chambers. Magnetohydrodynamics offers a unique solution to the basic problem of containing the reaction without contact with the chamber walls.

Briefly, the physical principles of magnetohydrodynamics are these. Since gas at such temperatures is completely ionized and is an effective conductor of electricity, the introduction of currents in the gas (in this state called a plasma) creates an electromagnetic field. This field makes it possible to control the plasma by applying an external opposing magnetic field which creates a magnetic bottle to contain the charged gas particles. Similarly, a magnetic-field piston can be used to accelerate the particles. Such magnetohydrodynamic reactions are expected to develop exhaust velocities that are an order of magnitude greater than those generated by present chemical rockets.

At Space Technology Laboratories, both analytical and laboratory work are proceeding in the field of magnetohydrodynamics. This work illustrates the advanced research in STL's Physical Research Laboratory, which emphasizes the application of basic physical principles to the requirements of space technology.

In support of its over-all systems engineering responsibility for the Air Force Ballistic Missile programs, and in anticipation of future system requirements, STL is engaged in a wide variety of research and experimental development activity. Projects are in progress in electronics, aerodynamics, propulsion, and structures.

The scope of work at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding the many opportunities on the Technical Staff are invited.

SPACE TECHNOLOGY LABORATORIES

A Division of The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA

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Sir Richard Southwell Is Visiting Professor at Rice

Sir Richard V. Southwell, an Institute Honorary Fellow, has joined the faculty of The Rice Institute, Houston, Tex., as Visiting Professor of Mechanical Engineering, until June.

The retired British educator, an authority in the field of relaxation methods and theory of elasticity, will teach an Applied Mechanics Seminar. This course will be based on a book planned by the educator. It will deal with the application of his previous book, *Relaxation Methods*, to various phases of applied mechanics—in particular, the theory of elasticity and structures. A series of public lectures also is planned.

Active in aviation since 1914, Sir Richard was Professor of Engineering Science at Oxford from 1929 to 1942. He spent the next 6 years as Rector, Imperial College of Science and Technology, London University. He has written four books and numerous technical papers and is a Fellow of the Royal Aeronautical Society.

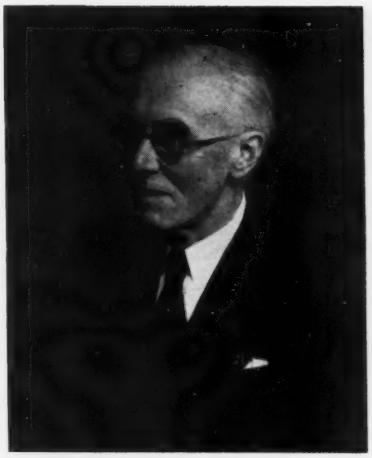
Sir Richard delivered the 1941 Wright Brothers Lecture on "New Pathways in Aeronautical Theory."

Bulova Laboratories New IAS Corporate Member

The Bulova Research and Development Laboratories, Inc., with headquarters at 62-10 Woodside Avenue, Woodside 77, N.Y., has become an Institute Corporate Member.

The firm has been engaged in development of a servoaltimeter of advanced design and capability for the past 2 years. For the measurement of altitude by pressure means, the instrument is currently in the small lot production phase.

Bulova says the instrument's main features are its tape presentation, extreme sensitivity, and accuracy. Basic sensitivity is said to be 0.01 in. of mercury



Sir Richard V. Southwell

throughout an altitude range of −1,000 to +80,000 ft., equivalent to a sensitivity of 2 feet at sea level. Accuracy is said to vary from 10 ft. at sea level to about 100 ft. at 80,000 ft.

H. W. Emmons to Deliver Three Minta Martin Lectures

The 1958 Minta Martin Lecture, "Combustion—An Aeronautical Science," will be delivered by Howard W. Emmons, 1957–1958 Hunsaker Professor of Aeronautical Engineering, Massachusetts Institute of Technology.

Sponsored by M.I.T. and the IAS, the lecture will be given March 10 at Kresge Auditorium, M.I.T., with the Institute's Boston Section participating. The Washington Section and University of Maryland are sponsoring the lecture on March 17 at the U. of M. campus, and on March 20 the Los Angeles Section and California Institute of Technology will hear the lecture on the Caltech campus.

NEWS OF MEMBERS

▶ **Major Gen. Albert Boyd, USAF (Ret.)** (F), has joined Westinghouse Electric Corporation as Consultant and Adviser to E. V. Huggins, Group General Manager, Defense Products.

▶ **Lt. Gen. Laurence C. Craigie, USAF (Ret.)**, just named a 1957 Fellow of the Institute, has also been elected a Vice-President of American Machine & Foundry Company. General Craigie also is a Director of Associated Missile Products Corporation, G. M. Giannini & Company, Inc., Giannini Research Corporation, and Hydro-Aire, Inc. His picture appears on page 23.

▶ **K. R. Herman** (M), President, Vickers, Inc., has been elected an Executive Vice-President of Sperry Rand Corporation.

▶ **Carl G. Holschuh** (M), President and General Manager, Sperry Gyroscope Company, has been elected an Executive Vice-President of Sperry Rand Corporation.

▶ **H. Guyford Stever** (F), Associate Dean, Massachusetts Institute of Technology School of Engineering, has been named head of a new NACA committee on space technology. Dr. Stever also is a 1958 IAS vice-president.

Members on the move . . . .

This section provides information concerning the latest affiliations of IAS members. All members are urged to notify the News Editor of changes as soon as they occur.

Charles W. Carmody (M), formerly the temporary Technical Development Coordinator of the Office of Air Traffic Control, Civil Aeronautics Administration, has been appointed to the new position of Assistant Director of the Office of Air Traffic Control. Mr. Carmody completed a contract as Civil Aviation Adviser to Greece this summer.

Capt. William E. Dean, USAF (A), formerly a Wing Material Staff Officer, 303d Bombardment Wing (SAC), Davis-Monthan AFB, Ariz., has been transferred to the Ballistic Missile Division (ARDC), Inglewood, Calif., and assigned as Airframe Project Officer for the Titan ICBM.

H. W. Holzapfel (M) has been promoted from Assistant Manager to Manager, The Garrett Corporation, AiResearch Aviation Service Division.

David J. Johns (M) has been appointed Lecturer, College of Aeronautics, Cranfield, United Kingdom. He resigned his position as Technical Officer, Armaments Division, Sir W. G. Armstrong Whitworth Aircraft, Ltd.

Ralph W. Johnson (M), formerly Structures Engineer at Radioplane Division of Northrop Aircraft, Inc., has been promoted to Senior Engineer. He also is a Project Stress Engineer on target missile projects.

Martin V. Kiebert, Jr. (M), formerly Director, Electronic Research, Applied Research, Inc., has joined Consolidated Electrodynamics Corporation.

John Dill McKenney (A) has been appointed Principal Engineer, Research and Development Section, at Clary Dynamics, the aircraft and automatic controls division of Clary Corporation, San Gabriel, Calif. Mr. McKenney is former Section Chief, Mechanical Systems Engineering, Jet Propulsion Laboratory, California Institute of Technology, and did not occupy the position incorrectly identified with him in these columns in the REVIEW for January.

Major Patrick W. Powers, USA (M), formerly assigned to the 1st Guided Missile Brigade, Fort Bliss, Tex., is stationed at Fort Leavenworth, Kan., where he is attending the Army Command and General Staff College.

Stanley T. Rader (A) has been appointed Southwestern District Sales Manager, Aircraft and Ordnance, The Weatherhead Company. He formerly was Sales Engineer, Stewart Warner Corporation.

Martin A. Snyder (M), formerly Flight Test Engineer, Lockheed Aircraft Corporation, Burbank, is now a Flight Test Engineer for the Lockheed Missile Systems Division, Van Nuys, Calif.

Werner Spilger (AF) has joined Aeronutronic Systems, Inc., as Research Scientist. Dr. Spilger formerly was with Lockheed's Military Operations Research Division.

(*IAS News continued on page 68*)

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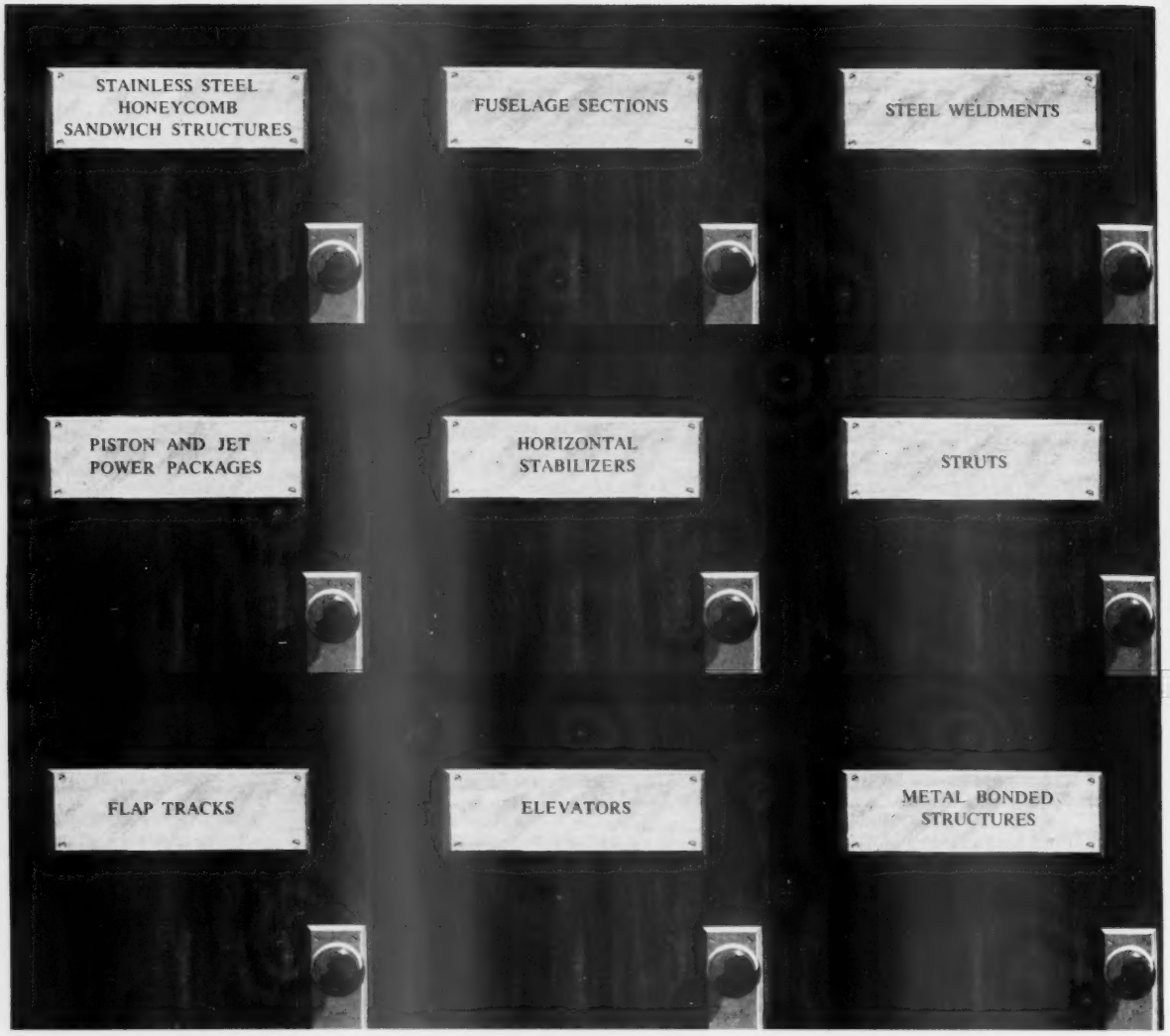

AIRCRAFT SPECIALISTS IN MANY FIELDS

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DATELINE World

PROFESSIONAL NOTES AND REPORTS

Engineering and Scientific Briefs from Correspondents Around the Globe

17 Satellite Articles in Soviet Publication

◆ Questions on the motion of artificial satellites, and their uses in scientific research, are examined by Soviet scientists in 17 technical papers in the September, 1957, issue of *Progress in the Physical Sciences*.

The 282-page issue commemorating the 100th anniversary of the birth of K. E. Tsiolkovskii includes articles on problems connected with the launching of a satellite, means of predicting orbit life (with a chart and tables), a method of calculating satellite motion with a digital computer, and some problems of the dynamics of a flight to the moon.

Other articles cover investigation of the composition of primary cosmic radiation, atmosphere investigations with rockets and satellites, use of satellites to study interplanetary solid matter, and silicon solar batteries as sources of electrical power for satellites.

Also discussed are verification of the general theory of relativity, solar ultraviolet radiation, and pressure, density, ionization, and electrostatic fields at extreme altitudes.

French Scientific Efforts Unified by Two Committees

◆ Two important committees are responsible for the cohesive relationship of scientific efforts in France. These are the Scientific Action Committee for National Defense and the National Committee for Scientific Research. There is no direct connection between them. *Comite d'Action Scientifique* (CASDN) is a high-level advisory group appointed by interministerial decree, responsible to the President of the Council of Ministers but attached to the Minister of National Defense, while the *Comite National de la Recherche Scientific* (CNRS) is a public institution, composed of civilian personnel under the authority of the Minister of National Education. However, an indirect relationship is shown through the membership of CASDN members in the administrative council of the CNRS.

CASDN is not solely responsible to the Defense Minister. The subtle but important difference in the French titles indicates that CASDN has broader scope of scientific interest than those matters which are conducted solely within the Ministry of National Defense. The President of CASDN and its members are appointed by, and are responsible to, the President of the Council of Ministers, and, because of this, the committee is in a position to coordinate all scientific efforts in France that have a bearing on national defense.

General of the *Corps d'Armee* Maurice H. Guerin is president of CASDN. The committee is composed of 14 leading civilian scientists. General Guerin has a personal staff consisting of a lieutenant colonel, a major, and a captain. The committee is supported by a permanent secretariat of 20 military personnel headed by a colonel. Rather than sponsoring or conducting any direct scientific research itself, this group (1) maintains contact with all research and development activities in France and (2) makes studies and recommendations to avoid duplication between the several military services and to assure optimum use of both military and civilian scientific talent and facilities. This is understood to be achieved not through a direct command line but through CASDN members functioning on director committees of many research establishments.

The National Committee for Scientific Research (CNRS) is a large organization established by public law, with a separate budget under the authority of the Minister of National Education. It coordinates, encourages, and stimulates scientific research in all areas and grants subsidies to private and public scientific establishments for various types of expenses. In addition, it administers and supports throughout France a large number of laboratories engaged in pure and applied scientific research in all fields. The members of CNRS are drawn from 13 different sciences divided into two classes:

Class A: Mathematics, Astronomy and Earth Sciences, Physics, Chemistry, and Biology and Experimental Medicine.

Class B: Human Sciences.

Although, as has been pointed out, there is no direct relationship between the two committees, their cross-membership and cooperative attitudes go far toward coordinating the nation's full scientific effort, and both are considered vital to the scientific health and welfare of France.

Soviet "Flying Stand" Is Described in Article

◆ A late 1957 issue of the Soviet publication *Soviet Russia* contained an article by L. Novikov on a platform type of aircraft (similar to the British "Flying Bedstead") called a "Flying Stand." In a photograph illustrating the article, it can be seen that the craft has a vertically installed jet engine, which protrudes above the central framework, with the exhaust nozzle extending below. The pilot apparently sits beside the jet intake. Landing wheels are mounted at the inboard end of projecting booms, which apparently support the air jets for control purposes.

The article states that the Flying Stand was built at a "scientific research institute," which remains unnamed. Personalities associated with the novel VTO aircraft were listed as A. N. Rafaelyants, designer; A. I. Kvashnin, chief engineer; G. I. Kobets, development engineer; G. M. Lapshin, engineer; Ya. A. Garnaev, test pilot.

Control was mentioned as a design problem; Novikov stated that two types of controls were found suitable to provide both stability and maneuverability, these being (1) a type "placed in the jet exhaust stream" and (2) controls which "work with help of compressed air from the jet-engine compressor."

Electron-Sensitive Emulsion Developed by Moscow Laboratory

◆ A report on the June, 1957, meeting of the International Conference on Cosmic Radiation states that a Moscow laboratory for cinematic photography has developed an excellent electron-sensitive emulsion. Photographic plates covered with such an emulsion are used to determine the nature of nuclear events in experiments using high-energy particles from accelerators (betatrons, etc.) and in cosmic-ray research.

Heretofore the Soviets had been dependent on a foreign source for reliable emulsions.

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EDITORIAL

Space Technology and the NACA

By Hugh L. Dryden

This important policy statement was prepared by Dr. Dryden for presentation as a luncheon address at the Institute's 26th Annual Meeting.

In Dr. Dryden's absence, it was delivered by John C. Victory, Executive Secretary of the NACA, on January 27, 1958.

The topic of our day is the new frontier, space, and the new challenge, the conquest of space. The escape of objects and man himself from the earth into space has long been the subject of science fiction writers and the comic strip artists. More recently, it has been a matter of interest to a growing number of serious-minded scientists. Now, it has acquired a new sense of imminence and reality. Space travel has stirred the imagination of man to an extraordinary degree. It is, however, one thing to desire to travel in space and quite another to satisfy that desire. Early accomplishment of this goal will require major advances in science and technology.

This effort will stimulate industrial and economic development. Space vehicles will open the way to acquisition of much new knowledge about the earth and the universe. They will enable development of new military weapons. They will bring great national prestige.

The launching of the first man-made satellite on October 4 of last year produced an extreme swing of the pendulum from general lack of interest in space travel, and even ridicule of its proponents, to expectation of early interplanetary flight. This essentially emotional reaction may make it extremely difficult to proceed with a sound program. Engineers have a special responsibility to be bold and imaginative, and yet they must be thoroughly realistic and practical. We must do our share in acquainting the public with the characteristic

Hugh L. Dryden, Director
National Advisory Committee for Aeronautics
James H. Doolittle, Chairman
National Advisory Committee for Aeronautics

difference between engineering and technology, and other professions and fields of endeavor.

In many professions—for example, law, education, diplomacy—the spoken or written word plays a dominant role in accomplishment. The lawyer prepares a brief with great care, but often the key factor is the skill with which he pleads his case and thus persuades others to accept his conclusions. Lawmakers debate the issues and resolve them by compromise and majority vote. Similarly in other fields—in sales and even in banking. A characteristic feature is that, when the discussion ends in decision, the result is immediately at hand. There is no time lag or only a very small time lag between decision and accomplishment.

In engineering there is also much discussion, debate, and compromise. But when decision is reached to build a bridge, an airplane, or a spacecraft, there remains the "hardware" construction. The materials of our physical world cannot be talked or argued into desired shape. There is a long time lag between the decision and the completion of the bridge, or airplane, or spacecraft. Like the time span between conception and birth of a child, no amount of discussion or investment of money can reduce this time interval to zero. Thus travel to the moon by manned or unmanned vehicles will require more than discussion, decision, and allocation of funds. It will require much effort and time and will be soonest achieved by a systematic and orderly program of research and development. The public must be understanding and patient with the scientists and engineers in addition to providing the necessary funds.

I wish to discuss with you briefly my own views as to what the national program should be, the role of research, and specifically the role of the NACA. In speaking of it as a national program, I do not wish to exclude the possibility of the program's becoming an international one; its technical character would be the same.

In my opinion, the goal of the program should be the development of manned satellites and the travel of man to the moon and nearby planets. I omit for the present travel outside the solar system since the probable travel times seem well beyond the adult life of an individual even with optimistic extrapolations of known science and technology. The immediate goals should be more limited, and these I will discuss a little later.

There is rather good agreement that there are at least three general aspects of an adequate space program. These are (1) research in space technology to provide data for the design of useful and efficient vehicles, the provision of a safe environment for man, and otherwise to ensure the success of manned space flight operations; (2) design and development of scientific and military space vehicles and their launching, flight, and recovery; and (3) research on the phenomena of the high upper atmosphere and nearby space, such as the character and distribution of matter, cosmic rays, solar radiation, electric, magnetic, and gravitational fields, etc., and scientific studies of the universe made possible by the use of satellites and space platforms as observation sites.

You know as well as I how eagerly those in astronomy, geophysics, and meteorology—to name only three of the interested scientific groups—anticipate the tremendous advantages that will result from such observation sites in space.

The development and operation of military missiles, military satellites, and military space vehicles are clearly a military function, and it is well understood that a vigorous program is necessary. It is not so well understood by the general public that additional vehicles and operations will be required for scientific research on space phenomena and scientific exploration of the universe, in addition to those employed for research in space technology. The national program must include both nonmilitary and military aspects. It is perhaps the nonmilitary aspects of space flight that will have the greatest impact on the thinking and the future of all mankind.

The organization of the national effort is receiving much study. The President and the Secretary of Defense have announced the formation of an Advanced Research Projects Agency within the Department of Defense to which responsibility for military space projects is to be assigned. Responsibility for nonmilitary aspects has not yet been fully determined. Some groups have recommended the creation of a completely new independent civilian agency of government to conduct research and development in its own laboratories or by contract, to contract for and sponsor development of components and vehicles, and to engage in space flight operations. Some of these proposals restrict the activities of the proposed new agency to nonmilitary projects; others include at least the research aspects of military projects.

The basic reason underlying these proposals for a new civilian agency is plain. The scientific community, understandably, is worried about the possibility that the extremely important nonmilitary aspects of space technology would be submerged, or perhaps even lost, if included as a mere adjunct to a military program.

There is another solution to the problem of how best to administer the national space-technology program, one which clearly recognizes the essential duality of our goals—the prompt and full exploitation of the potentials of flight into space for both scientific and military purposes. Actually, this solution is old and well tested. It is explicitly stated in the 1915 legislation that established the National Advisory Committee for Aeronautics with responsibility to "supervise and direct the scientific study of the problems of flight, with a view to their practical solution. . . ." The Committee structure of the NACA embraces both the nonmilitary and the military elements of aeronautics. The researches of the NACA are designed to be useful to both the nonmilitary and the military segments of aeronautics. The entire operation of the NACA is based upon the premise that coordinated teamwork effort by all

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parties concerned provides the surest guarantee of progress in aeronautics.

At its meeting on January 16, 1958, the NACA expressed its view that the national space program can be most rapidly, effectively, and efficiently implemented by the cooperative effort of the Department of Defense, the NACA, the National Academy of Sciences, and the National Science Foundation, together with universities, research institutions, and industrial companies of the nation. Under this plan, the National Science Foundation in collaboration with the National Academy of Sciences would plan scientific experiments and assign priorities for research on space phenomena for basic scientific purposes as previously described. The National Science Foundation would assume responsibility for financial support of scientists in the detailed planning, design, and construction of special apparatus, related research, and analysis of data for approved projects. The NACA would conduct flights for scientific purposes when within its capabilities, or jointly with appropriate agencies of the Department of Defense, in the successful pattern of the research airplane programs. The NACA would also coordinate and conduct research in space technology in its own laboratories and by contract in support of both military and nonmilitary projects.

Since the end of World War II the NACA has been engaged increasingly in research applicable to the problems of space flight and has designed and constructed the special aerodynamic, structural, and propulsion facilities required for this work. For example, studies were formally initiated in 1952 leading to the X-15 research airplane project, a cooperative project involving the NACA, Air Force, and Navy. North American Aviation is now building the X-15, and it is scheduled to make its first flight in about one year. The X-15 will be used to explore problems of manned flight into nearby space, particularly the control of the attitude of the vehicle in space in the absence of aerodynamic forces, the safe return from space to the atmosphere without destructive heating, and the effect of weightlessness on the pilot.

The NACA is also engaged in studies of satellite configurations suitable for safe re-entry at still higher speeds, both for manned and unmanned flight. The present program is far from adequate. Our rate of progress in solving the problems of space flight must be greatly increased. The problem is essentially one of extension and expansion of effort. For this purpose new research facilities will be needed at existing laboratories and at new laboratories, including a launching site for space flights for research purposes. A larger staff will of course be needed. A greatly expanded contract research program is similarly essential to obtain assistance from groups with special competence in specific areas. Thus special talents, experienced staffs, and facilities of existing organizations can be pooled for the accelerated effort that is required. I would emphasize that these organizations already have demonstrated that they can work together successfully and, perhaps equally important, that they have established the necessary close relationships with the scientific community and with industry.

To provide material assistance in its program, the NACA recently appointed a Special Committee on Space Technology under the chairmanship of Dr. H. G. Stever, Associate Dean of Engineering of the Massachusetts Institute of Technology. A partial list of the members of the new committee includes:

H. Julian Allen, Ames Aeronautical Laboratory
Dr. Hendrik W. Bode, Director of Mathematical Research, Bell Telephone Laboratories
Dr. Milton U. Clauser, Director of Aeronautical Laboratory, The Ramo-Wooldridge Corporation
Prof. Dale R. Corson, Cornell University
James R. Dempsey, Manager, Astronautics Division, Convair
Robert R. Gilruth, Langley Aeronautical Laboratory
S. K. Hoffman, General Manager, Rocketdyne Division, North American Aviation, Inc.
Dr. W. Randolph Lovelace, II, Lovelace Clinic
Dr. William H. Pickering, Director, Jet Propulsion Laboratory, California Institute of Technology
Dr. Louis N. Ridenour, Jr., Missile Systems Division, Lockheed Aircraft Corporation
Abe Silverstein, Lewis Flight Propulsion Laboratory
Dr. James A. Van Allen, Department of Physics, State University of Iowa
Dr. Wernher von Braun, Director, Development Operations Division, Army Ballistic Missile Agency.

The Committee will also include representatives of the Air Force and Navy not yet designated.

This Committee will take a fresh look at the research and development problems of space technology and make recommendations as to the needed programs. The first meeting of the Committee has been scheduled for February 13. The major research fields which must find a place in the overall national program include space mechanics; space environment; energy sources; propulsion systems; vehicle configuration and structure; materials; launch, rendezvous, re-entry, and recovery; communication, navigation, and guidance; space biology; flight simulation; and measurement and observation techniques.

The design and development of vehicles should proceed simultaneously with research on space technology. While the goal is manned flight to planets within the solar system, the vehicle program must proceed in step-by-step fashion. We have something to learn from the U.S.S.R. experience. So far as we know, they began as did we—with a supply of German V-2 rockets and the aid of German scientists and engineers. In contrast to our own development, their program proceeded in logical steps with consistent support from top government officials and at high priority. Larger and larger rockets were developed by the U.S.S.R. scientists leading to ballistic missiles of steadily increasing range, with many missiles built and fired. A group was organized for scientific work on phenomena in the high atmosphere using rockets. In addition to physical apparatus, animals were sent aloft, including dogs. As experience was gained and reliability in

(*Continued on page 44*)

" . . . man's adaptability, the engineer's ingenuity, and the flight surgeon's ability to meet and solve the problems of maintaining man's homeostasis in all environments will conquer the vertical frontier."

The Environment of SPACE in Human Flight

Major Charles A. Berry, USAF (MC)
School of Aviation Medicine, Randolph AFB

SINCE THE DAWN of his existence man has been conquering his environment whether it be land, sea, or air. The vertical frontier now stands with an open door and beckons us on to the outer reaches of our planet's atmosphere and space. The very thought of space has long occupied man's imagination yet still has produced an awesome mental picture of a black, cold, hostile area of nothingness far out on the vertical frontier. As flight surgeons and specialists in aviation medicine, we are concerned with the hazards that this hostile environment presents for our space pilots of the future. In present-day aviation medicine, our concern has not been limited to the lower atmospheric shells but has encompassed brief exposures to the upper borders of the stratosphere (126M′) by Kincheloe. (M′ = 1,000 ft.) Thus aviation medicine has already been confronted with "space" flight problems and needs only to expand its interest further vertically to cope with the problems of true space flight. It is the purpose of this paper to define "space" as an environment for man and to indicate that present-day operations are carried on in "space" as far as man's physiology is concerned.

Space Equivalence

The conventional atmospheric chart showing the level of the exosphere with its few remaining ions of air at 600 miles must be discarded when we consider man. Dr. Hubertus Strughold published a paper in 1954 in which he discussed the concept of "space equivalent" altitudes. This study delineated a zone of "physiological insufficiency" starting at an altitude of 10M′ and extending to 50M′, a "partially space equivalent" zone extending from 50M′ to 120 miles, and a "total space equivalent" zone above this altitude (Fig. 1). The loss or change of certain of the atmosphere's properties create difficulty for man then at very low altitudes.

This paper was presented at the Space Medicine Session, IAS 26th Annual Meeting, N.Y., Jan. 27–30, 1958. (IAS Preprint No. 796.)

The author is in the Department of Aviation Medicine.

Oxygen

The reduction in overall pressure and resultant decrease in partial pressure of oxygen creates a problem in supplying this vital element. The problem has existed since the first days of balloon flight and numerous means of providing adequate oxygen have been developed. These have been summarized in Fig. 2. The partial pressure is such that from 10–34M′ mixtures of ambient air and oxygen may be supplied by an automatic regulator and provide adequate oxygenation. At 34M′ the oxygen partial pressure in the lungs when breathing 100 per cent oxygen is the same as when breathing air at sea level. At altitudes of 34–40M′ 100 per cent oxygen will suffice, but from 40–50M′ pressure must be added. At 50M′ the ambient pressure reaches levels where, due to alveolar pressures of the various gases, the physiological effect is the same as if there were no oxygen and the time of useful consciousness reaches a constant of 12–15 sec.

It becomes necessary to supply the oxygen under

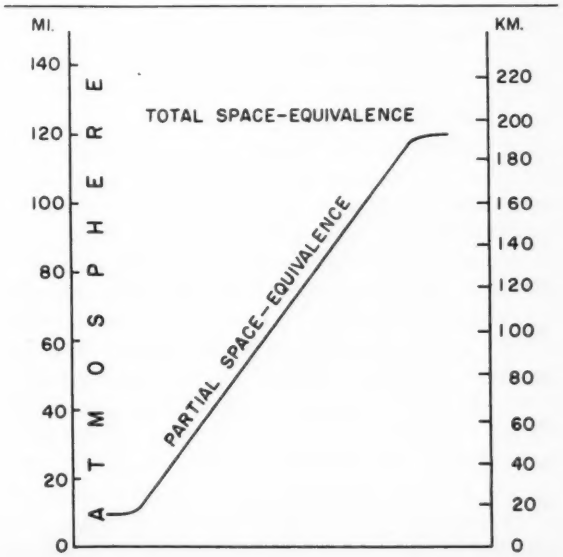

FIG. 1.

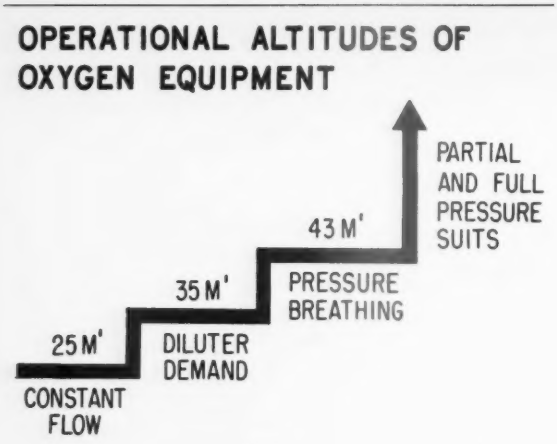

FIG. 2.

even more pressure. In order to prevent pooling of fluid in the extremities as well as other complications, counterpressure must be supplied to the body. A series of partial pressure suits has been designed and these have provided protection up to 200M′ for prolonged periods. Though his garment will protect against the space equivalent condition of low oxygen tension it still places a man at the equivalent of 40M′ breathing 100 per cent oxygen. A better and more physiological answer would seem to be the full pressure suit recently demonstrated by the Aeromedical Laboratory. Though there is no doubt this garment will protect man from the lack of oxygen, work still needs to continue to improve the mobility, strength, and comfort in order that man may withstand the rigors of a walk on the moon.

TOTAL PRESSURE

Dysbarism

The well-known decrease in pressure with altitude creates many problems for man due to the gases in his body responding to the laws of Boyle and Henry. You are all familiar with the expansion on ascent and contraction on descent of the gases in the middle ear and sinuses, a phenomenon routinely experienced even in conventional airline flight. The entire symptom complex resulting from a decrease in total atmospheric pressure we have termed dysbarism. In addition to ordinary expansion of gases in the ear, sinus, and intestine, the reduction in pressure releases nitrogen which is in solution in the blood and tissues. This bubble release combined with other mechanisms probably produces the more severe dysbarism symptoms of bends, chokes, various neurological disorders and neurocirculatory collapse, and death. Though deaths have been few both in the training (pressure chamber) and operational (aircraft) situation, we are seeing more severe cases which disable the pilot, at least temporarily and perhaps longer.[2] Denitrogenation by breathing 100 per cent oxygen at ground level for approximately 2 hours has been a good prophylactic measure, as well as the more obvious one of maintaining the microclimate about the man at an altitude below 30M′. Symptoms of severe dysbarism are rarely seen below this altitude.

Ebullism

Another effect of the decreased total pressure which is of concern to the human going to space is the so-called "boiling" of body fluids. Ward[14] has discussed the factors determining the onset of this phenomenon and suggested the term "ebullism" because boiling in common usage carries the implication of an increase in temperature. It is important to realize that vaporization of body fluids begins at ground level and varies for different parts of the body with temperature, decreasing atmospheric pressure, and the solute content of the body fluids. Beischer[1] has reported studies on various frogs and worms exposed to 5 mm. Hg pressure for several hours. Marked dehydration occurred because of vaporization and evaporation of body fluids at the surfaces. These animals were not explosively decompressed however. Intravascular ebullism will surely occur in man with acute exposure to altitudes approximating 63M′. As the total pressure at this altitude is only 47 mm. Hg—equal to the commonly accepted value for water vapor pressure, this altitude (63M′) has been felt to represent the absolute demarcation line for the onset of ebullism. This is not so, however, as temperature and the body fluid solutes may allow this to vary between 63,000′ and 67,000′. Intrathoracic water vapor producing a vapothorax may form at altitudes as low as 61,500′.

Ozone

Spectrographic measurements both in this country and in Germany have revealed an area of increased ozone content greatest between 70 and 100M′ with little or none above 120M′.[6] This ozone is produced by the action of ultraviolet, in wavelengths less than 2000 Å, on ordinary oxygen. The atmospheric concentration varies with the season and with geographic location as shown in Fig. 3. The concentration is lower in the fall and higher in the spring. What significance does this hold for man? Clamann[4] has reported studies on the physiological effects of ozone in five human subjects. Though there were great individual differences in sensitivity, irritation of the respiratory tract was observed at concentrations as low as 0.6 ppm for exposure times of 30 min. Gross changes in respiratory function (50 per cent reduction in vital capacity and onset of pulmonary edema) were noted after exposures to 6 ppm for 1 hour. Its toxicity is graphically illustrated by the maximum allowable concentration (for an 8 hour daily exposure for a year) being 0.1 ppm compared to 100 ppm for carbon monoxide and 1 ppm for phosgene or chlorine. The effect of ozone on rubber is well known and intermittent exposure of equipment such as oxygen masks to even 1 ppm for 100 hours has resulted in severe deterioration. This points up the need to use such ozone resistant products as neoprene, the silicones, or hypalon.

The newer compressors are capable of utilizing ambient air for cabin pressurization up to an altitude of 80M′. As exposure to heat for 1 sec. will destroy ozone, it has been hoped that in passing ozone laden air through the compressor the resultant heat would reduce the ozone content to zero. Unfortunately, the very efficiency of these new compressors depends on their speed thus reducing the contact time of air with heat to a level where less than 50 per cent of the ozone is destroyed. Though this absolute concentration is small, it is increased as much as ten times by returning it to near sea-level conditions in the cabin. Some filter design will be necessary. The photochemical production of nitric oxide (NO) in the region of roughly 300-400M′ has not been as well studied.

Cosmic Radiation

Above approximately 120,000 ft. man will be exposed to the heavy primary cosmic rays. These rays are mainly protons with some nuclei of helium and other elements up to at least iron and cobalt. They arrive from all directions in almost equal number, so the cosmic ray flux may be considered to be of uniform density at all points. Each of these extremely high energy particles eventually strikes a nucleus of another atmospheric particle creating a veritable avalanche of secondary particles. It is believed that the effects of this radiation on man will be like that of other known radiations (x-ray, gamma, etc.).

Meteors

Above 400,000 ft. any vehicle will be exposed to the hazard of collision with a meteor which could range in size from a dust particle to many tons. Whipple estimates that an earth satellite with a radius of 20 in. and skin thickness of 0.5 mm. aluminum will be punctured once in 5 days.[9] This is more frequent than estimates made earlier by Whipple,[15] and also by Grimminger[7] who estimated that a 1,000 sq. ft. area would suffer a penetration hit once in about 15 years. Erosion of vehicle surfaces by meteoritic dust may be a more common hazard.

The satellite projects should provide much more accurate information in this regard. The suggestions for a meteorite bumper[15] and compartmentation of the cabin[10] are possible means of protection.

Solar Radiation

Ultraviolet radiation, unscreened by the ozone layer, produces a serious sunburn hazard to unprotected man above 120,000–140,000 ft. Ordinary glass and most plastics are good absorbers of this portion of the spectrum (3000 to 2100 Å).

The twilight of space has been reported by observers in present-day balloons and aircraft. At 400,000 ft. this loss of scattering power, due to the small numbers of molecules available, reaches space equivalence. This same scarcity of air molecules prevents the propagation of sound waves at this altitude.

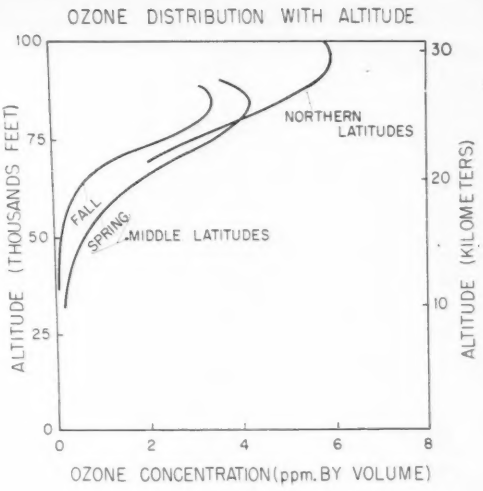

Fig. 3.

If a body is maintained at rest in relation to the ambient air, a pure radiation equilibrium could be attained at an altitude of approximately 30 miles. At the expected speed of an orbital vehicle the radiation equilibrium would not be reached under an altitude of 150 miles. The temperature equilibrium will depend upon many variables such as the vehicle's position in relation to the other radiating bodies (the sun and the earth), its movement (spin or wobble), the nature of its surface, and its thermal capacity per unit area. The vehicle may face space, the sun, and the light or the dark earth all in one orbit. Piccard[11] reported difficulties in this regard as early as 1931 when he had painted one side of his balloon gondola black and left the other shiny. He hoped to control the temperature of the gondola by rotating the required side toward the sun. The rotation mechanism failed however with the black side toward the sun and the temperature inside the gondola rose to 95–104° Fahrenheit. If the vehicle's orbit could be arranged to coincide with the great circle dividing the earth into its sunlit and dark hemispheres, it would remain in the sun's illumination. Buettner[3] calculated the equilibrium temperatures of white, black, and polished aluminum surfaces both facing the sun and then facing the sunlit earth and the dark earth. These figures show a higher equilibrium temperature for the polished aluminum surface than for those painted white or black, thus suggesting painting the surface of spacecraft. Man's tolerance to heat requires further testing, but he should not be expected to endure the dermal pain produced by temperatures of 44.8°C.[3] The problems of heat produced by speed will be discussed in another paper.

Weightlessness

This peculiar phenomenon has received much attention lately and has been studied by producing it experimentally in parabolic flight in jet aircraft. The problems of eating, drinking, performance, etc. seem

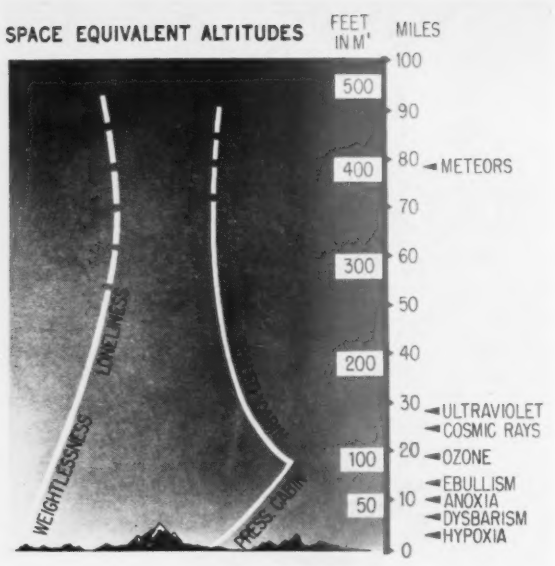

FIG. 4.

solvable. This is the one condition mentioned thus far which is not a function of altitude or distance from the earth's surface. Though the force of gravity does decrease with increasing distance from the earth's surface it will always exert some minute force. The density of the atmosphere acts only to limit the duration of the gravity free state. The condition of weightlessness must be produced by the speed of the vehicle being such that centrifugal force balances the gravitational pull of the earth.

SEALED CABIN

Many of the above mentioned effects have been problems faced by present day aircraft, and the pressurized cabin was introduced as a means of protection. The continued development of protective equipment attests to the fact that these cabins, like most man-made devices, are not foolproof or 100 per cent trustworthy. Even if they were this reliable, the use of such a pressurized cabin is limited by altitude, the pressure differential, and the heat produced by trying to compress the thin air. The only solution seems to be placing man in a sealed cabin where his microclimate can be totally controlled. The integrity of even this device may be compromised, however, most likely by meteorite penetration. Thus a basic decision must be made as to where the line will be drawn on providing safety and emergency equipment. Should we try, and is it possible to save the man if the best designed cabin system should fail? Our humanity and our pride as flight surgeons demand that we do the utmost to provide every possible means of protection against the hostile environment. Thus, even in the sealed cabin a pressure suit will be necessary in case of cabin failure and later to allow any exploration outside the cabin.

The sealed cabin must be a complete synthetic world independent of the ambient atmosphere. The most critical function of this little world will be the providing of adequate oxygen and the removal of carbon dioxide. Liquid oxygen will most likely be used in our early ventures into space. An average value of 1 cu.ft. of oxygen per hour must be available.

The deleterious action of carbon dioxide on mental function is a time-concentration phenomenon and for indefinite periods should be maintained below 1 per cent of ground level atmospheric pressure (8 mm. Hg). Chemical absorbents such as sodium hydroxide, soda lime, and other alkalies are the only practical methods of removal at present. Their weight will preclude their use on long flights however. Photosynthesis by using a live system (algae), and photochemical methods of decomposition of carbon dioxide are under consideration for the future.

Temperature and humidity control must be provided by advanced air-conditioning techniques. Odor removal is purely aesthetic, for calculations have shown that the first physiological effect of flatus in a 100 cu.ft. cabin occupied by one man would be tearing of the eyes due to hydrogen sulfide. It would take 2,000 days of exposure to reach fatal H_2S levels.

Waste (urine and feces) disposal and recycling have been investigated recently at the School of Aviation Medicine. Filtration and evaporation of urine for reuse have shown promise.

The psychological problems presented by the exposure of man to an isolated, uncomfortable void seem to be more formidable than the physiological problems. A recent 24-hour "flight" in the School of Aviation Medicine space-cabin simulator pointed up such problems as the extreme loneliness experienced even though the subject knew the simulator was still on the ground.

The stresses to be encountered by the space pilot are thus many, and these stresses are summarized in Fig. 4. Careful selection for both physical and mental attributes will be necessary. Testing all possible stresses on various simulators will be a valuable tool in this selection.

The problems presented by space as an environment for human travel are thus extensions of those encountered in present-day flight. The environment of the sealed cabin necessary to protect the space traveler against the hazards of the ambient environment will itself produce new problems such as isolation, but this too has been described in jet flight as the "break-off phenomenon."[5] I have great faith that man's adaptability, the engineer's ingenuity, and the flight surgeon's ability to meet and solve the problems of maintaining man's homeostasis in all environments will at last conquer the vertical frontier.

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(*Continued on page 60*)

XUM

A high-speed electronic computer program is presented for calculation of axially symmetric flow around bodies of revolution by the method of characteristics. The capabilities of electronic computers are considered in the reduction of the differential equations of the method of characteristics to difference equations. The important computer logic portion of the program is also based upon the capabilities of electronic computers, as well as upon a knowledge of aerodynamic phenomena.

Calculations by the Method of Characteristics

R. D. Linnell

Convair, A Division of General Dynamics Corporation

THE WELL-KNOWN method of characteristics provides a procedure for numerical integration of the governing equations for inviscid supersonic plane and axial symmetric flows of a perfect gas.[1-5] In this method the original partial differential equations reduce to total differential equations when integration is restricted to paths along the *characteristics* which are defined by

$$dy/dx = \tan(\theta \pm \mu) \qquad (1)$$

where the inclination of the velocity vector θ and the Mach angle μ are point functions of x and y in the coordinate system shown in Fig. 1.

Physically, Eq. (1) shows that the characteristics are the local Mach lines which are inclined to the local velocity vector by the Mach angle. There are two characteristic lines at any point—one inclined to the left of the velocity vector when facing downstream (the plus sign in Eq. 1), the other inclined to the right.

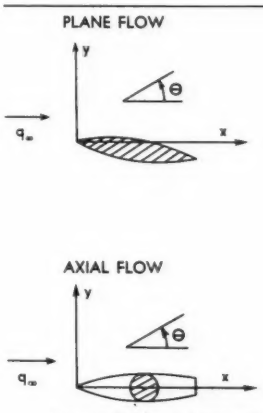
The corresponding total differential equations can be written

$$dq/q \mp \tan\mu\, d\theta = + \epsilon[\tan\mu \sin\mu \sin\theta/\sin(\theta \pm \mu)]\,(dy/y) - (\sin^2\mu/\gamma R')dS' \qquad (2)$$

which are called the compatibility equations because they are compatible only with integration along the characteristics. The local velocity divided by free-stream critical sound speed is denoted by q; the symbol ϵ has the value unity for axial symmetric flow and is zero for plane flow; the ratio of specific heats of the gas is denoted by γ; R' is the gas constant in mass units—e.g., 1,715 ft.^{2}/sec.^{2} °F.; and the entropy of the gas is denoted by S'.

Eqs. (1) and (2) determine the flow conditions at the new point N shown in Fig. 2 when conditions at the nearby upstream points R and L are known. The equations of the short-dashed segments of the characteristics are written in terms of the averages of θ and μ at the two ends of each segment, by use of Eq. (1), and solved for y_N.

When the differentials in Eq. (2) are written as differences, use of the value of y_N produces a pair of simultaneous linear equations for q_N and θ_N if dS' is zero. Iteration is then employed to refine the average values used. Finally, all the flow conditions, pressure, density, etc., at N can be obtained from q_N and S_N' by means of the equations shown in the Appendix. When the new point is behind a shock, the oblique shock equations shown in the Appendix are required in addition to the above equations.



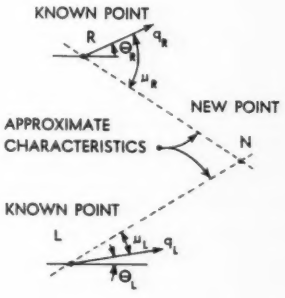


FIG. 1 (*left*). Plane and axial symmetric coordinates.
FIG. 2 (*right*). Field point calculation.

Several other special cases, in addition to the determination of a new point in the flow field just discussed, will be described later.

The Computer Capabilities

An electronic computer is made up of computing components and storage components of finite capacity. Numbers which are to be added, etc., are stored at locations which are designated by machine addresses and used in a manner similar to that of column numbers used in hand computing. These address locations are called for in the *program* which guides the com-

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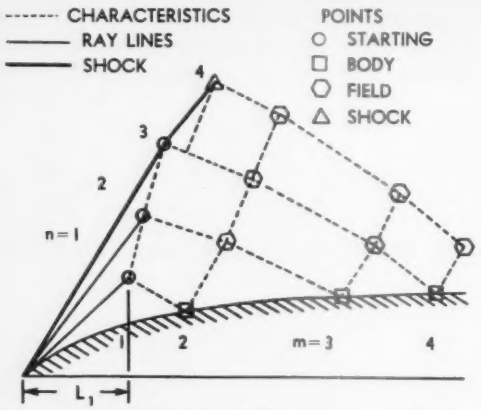


FIG. 3. Schematic of characteristics grid.

putation. The *logic* is the special part of the program which specifies where the known-point data are to be found, where the resulting new point data are to be stored, when iteration should be stopped, etc.

Since the storage capacity is finite, minimization of storage requirements is desirable when a complex program such as the present one is being programed. Another important consideration in programing an electronic computer is that machine time is expensive, so running time should be saved by eliminating unnecessary computational steps.

When the program is designed, the locations of data must be converted into whole number addresses which can be used by the machine. Similarly, the logic opertions must be expressed in terms of whole numbers plus the numerical operations which can be performed by the computing components of the machine.

Most machines will stop when given a mathematically impossible operation such as division by zero. When the machine stops on a long, complex program, it is desirable to have the machine print out the location and reason for the stoppage. Thus errors in the input data, or impossible cases such as bodies that would physically produce a detached shock with subsonic flow, can be easily found.

These four properties of electronic computers are taken into account in the computer program presented here.

TABLE 1
Sequence of Operations

Use	Apex Slope			to obtain	Raylines
Use	Right (1, 1)	and	Body Data	to obtain	Body (1, 2)
Use	Left (1, 1)	and	Ray 2	to obtain	Starting (2, 1)
Use	Right (2, 1)	and	Left (1,2)	to obtain	Field (2, 2)
Use	Right (2, 2)	and	Body Data	to obtain	Body (2, 3)
Use	Left (2, 1)	and	Ray 3	to obtain	Starting (3, 1)
Use	Right (3, 1)	and	Left (2, 2)	to obtain	Field (3, 2)
Use	Right (3, 2)	and	Left (2,3)	to obtain	Field (3, 3)
Use	Right (3,3)	and	Body Data	to obtain	Body (3, 4)

The Difference Equation

For machine calculation Eq. (2) is converted into a difference equation. Along a short segment of a left characteristic through a known point L, as shown in Fig. 2, the differential dq is replaced by $q_N - q_L$, and similarly for the other differentials. The values of q, θ, y, S', and μ in the coefficients of the differences are replaced by their average between the known point L and the new point N. The compatibility equations can then be written

$$\left.\begin{aligned} q_N - A_L\theta_N &= q_L - A_L\theta_L + \\ &\qquad B_L/\sin(\bar{\theta}_L + \bar{\mu}_L) - C_L \\ q_N + A_R\theta_N &= q_R + A_R\theta + \\ &\qquad B_R/\sin(\bar{\theta}_R - \bar{\mu}_R) - C_R \end{aligned}\right\} \quad (3)$$

where

$$\left.\begin{aligned} A_L &= \bar{q}_L \tan\bar{\mu}_L \\ B_L &= \epsilon\bar{q}_L \tan\bar{\mu}_L \sin\bar{\mu}_L \sin\bar{\theta}_L (y_N - y_L)/\bar{y}_L \\ C_L &= \bar{q}_L \sin^2\bar{\mu}_L (S_N' - S_L')g_1 \end{aligned}\right\} \quad (4)$$

with another set similar to Eq. (4), in which the subscript L is replaced by R. The bars indicate average values. Usually, the averages of A, B, and C are specified, but the present method requires fewer computational steps. Both procedures reduce to the differential equation in the limit of small steps. The constant g_1 depends on γ as shown in Eq. (A3) in the Appendix.

THE COMPUTER PROGRAM

The computer program is designed to compute the flow at the intersections of a grid of characteristics in an axial symmetric flow around a body of revolution as shown in Fig. 3. The address system for the computer logic uses the natural coordinate system provided by the characteristics. The right characteristic lines are designated by integers n, and the left characteristic lines by integers m. Each point at which the flow is calculated is thus designated by a pair of integers (n, m) for machine addresses.

In order to start the calculation, the flow in a small region near the apex of the pointed body is approximated by using the flow around a fictitious tangent-cone formed by the nose tangents. The flow properties in this conical flow are constant on ray lines from the apex. Thus, the flow condition at (1, 1) can be determined. By selecting the distance L_1, the body point (1, 2) can be calculated. Only one equation is needed since θ is known at (1, 2) because the flow must be tangent to the body.

The starting point (2, 1) can also be determined by using the left characteristic from (1, 1) and the next outward ray. Since (1, 2) and (2, 1) are now known, the field point (2, 2) can be calculated. Having (2, 2),

the second body point (2, 3) can be obtained. Thus, the characteristics network is constructed, proceeding downward to the right along a right characteristic each time.

These steps are summarized in Table 1, where each section comprises one complete right characteristic down to the body. Inspection of the table reveals an orderly sequence for the addresses. For example, a starting point is required following the calculation whose result is $(n, n + 1)$. The address for a starting point is found by adding 1 to the value of n that initiated it, and using $m = 1$ always. Only the first few calculations are shown in Table 1 to illustrate the procedure.

General Design

The input data provided to the program must include the coordinates of the body with provision for handling nonuniformly spaced body ordinates. The location of corners—that is, points at which the slope is discontinuous—must be given. The free-stream Mach Numbers for which the flow is to be calculated must be specified.

The choice of output data will depend upon the purpose of the general program. Data for points on the body surface only will usually be sufficient. The axial location of the point, the pressure or pressure coefficient, the Reynolds Number factor, ρqx, the Mach Number, and the temperature are useful. The wave drag coefficient can also be calculated.

Three special subroutines should be used in the program in order to reduce requirements for machine storage. These are for (1) the solution of a pair of simultaneous linear algebraic equations, (2) the slope of a straight line through two known points, and (3) for linear interpolation between two known values.

Iteration should be continued until the difference between two successive values of the velocity at the new point is less than a small fraction of free-stream velocity. A limit on the number of iterations should also be provided in order to prevent the machine from running away.

If the calculated value of sin μ is greater than 1, it should be reduced to 1 for iteration. If the value remains greater than 1 even after iteration, the program should be stopped with a print out of the location of the point and the explanation "subsonic flow."

The Calculation Procedure

The calculation procedure consists of evaluation of several types of points as identified by location in the characteristics network, in the manner indicated previously. Each type of point is discussed here in the order in which it first appears in the body problem. The notation used must be converted to machine addresses during the coding of the program.

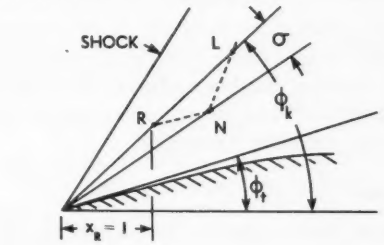
Conical Flow

The program is started by calculating the conical flow around the nose tangent-cone. The semiangle of the tangent-cone is obtained from the body ordinates by fitting them with, say, quartics.

For an assumed conical shock angle ω, the flow on the rayline just behind the shock is obtained from Eq. (A2) in the Appendix. Then Eq. (3) is used to calculate the flow between the shock and the tangent-cone. The two known points are selected on a rayline, see R and L in Fig. 4, so that q and θ are identical for them. The x location of R is selected as 1; however, there must be no restrictions on x, such as corner location checks, in the conical flow calculation. The equations for the new rayline and RN are written and solved for x_N, y_N. Next, the location of L is found by solution of the equations for the old rayline and NL. Conditions at the new point can then be obtained from Eq. (3). S' is constant at the value behind the shock because conical flow is irrotational. Iteration is used for each step.

Integration is continued inward until θ becomes larger than ϕ. Then a linear interpolation is used to find the cone semiangle, at which $\phi_t = \phi = \theta$. The assumed shock angle is changed until the resulting cone angle is equal to the tangent-cone angle. The angular step σ needed for the above calculation is selected as an integral fraction, say 1/10, of the angle between the shock and the cone.

The basis for the procedure for estimating and correcting the assumed shock angle is the solid part of the curve shown in Fig. 5. The curve is constructed by the machine, which uses the slope of the curve for correcting ω. The zeroth estimate for ω is $\mu_\infty = \sin(1/M_\infty)$. The corresponding cone angle is always zero. An increment, say 0.1 radian, is added to the first estimate to obtain a new shock angle. In succeeding corrections the difference between the calculated and desired cone angles is divided by the slope of the ϕ_t vs. ω curve, with 0.1 radian as a limit. The calculation can be refined by reducing the limit to 0.01 radian after the calculated angle exceeds the desired cone angle.



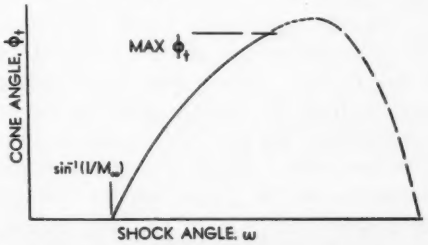


FIG. 4 (*top*). Conical flow calculation.
FIG. 5 (*bottom*). Typical curve of ϕ_t versus ω.

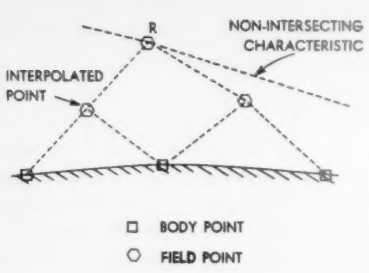


FIG. 6. Interpolation in body point calculation.

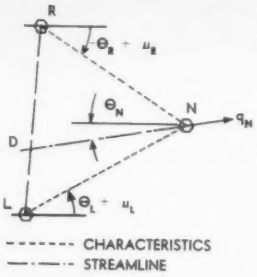


FIG. 7. Calculation of entropy, S'.

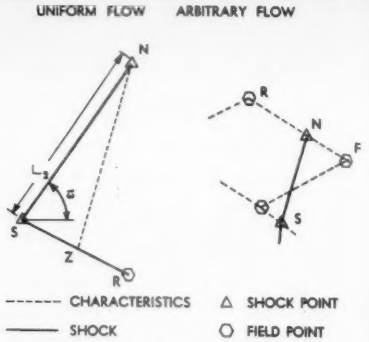


FIG. 8. Shock point calculation.

If the tangent-cone angle exceeds the maximum cone angle indicated in Fig. 5, then the calculated cone angles will increase until subsonic flow occurs behind the shock. The program can be stopped immediately, or the condition can be checked by reducing the maximum shock-angle correction to 0.01 radian and repeating the last calculation.

Body Point

The location of the first body point is found by solving the equation for a right characteristic from the rayline $\phi = \phi_t$ at $x = L_1$ simultaneously with the fitted equation for the body, by iteration. The geometry is shown in Fig. 3. Since $\tan \theta_N$ must be equal to the body slope at the new point, the compatibility equation for right characteristics then gives q_N directly.

The distance L_1 is initially selected as 1/10 the body length and is reduced until the difference between the velocities on $\phi = \phi_t$ and at the body is less than value required for terminating iteration in general.

It is possible that the right characteristic line will not intersect the body. If this occurs after the first body point, a right characteristic line is constructed from the midpoint of the left characteristic between the previous point on the body and R, as shown in Fig. 6.

When the iteration for the body point is completed, a test is made to determine whether a corner has been passed. If a corner has been passed, the angle at the corner is determined and either an expansion corner or a shock corner procedure is required.

Starting Point

The conical flow region is terminated by the first body point and a series of starting points, as shown in Fig. 3. The only requirement for the starting points is to select a geometric location on the next outward conical flow rayline. This is done by extending a left characteristic from the starting point on the previous rayline outward to the new starting point. The location of the new point is found by simultaneous solution of the equations for the rayline and the characteristic.

When a new starting point has been calculated, a new right characteristic line can be calculated down to the body. To do so, field point calculations are needed.

Field Point

The calculation of a field point when S' is constant was discussed in the Introduction. For rotational flow S' must be determined in order to solve Eq. (3). It is determined by constructing an approximate streamline of slope $\tan \theta_N$ through the new point, as shown in Fig. 7. The location of point D is found by simultaneous solution of the equations for the streamline and the line through R and L. The entropy at N is then taken as the entropy at D, which can be found by linear interpolation of the entropy values at R and L.

Shock Point

When the right characteristic from the last starting point, located just behind the conical shock, has been constructed down to the body, a shock point is needed to continue the calculations. The flow ahead of the head shock which starts at the body nose is the uniform free stream, but the flow ahead of a shock which starts from a shock corner point is arbitrarily nonuniform. The two cases are treated differently.

The new point is just behind the extension of the shock, as shown in Fig. 8. The shock angle for the new segment is taken as the value for the previous segment in the first approximation. The equation of the new segment is $y_N = y_S + (x_N - x_S) \tan \bar{\beta}$, where $\beta = \omega + \theta_1$ is the angle of the shock with respect to the x-axis.

On the head shock the length, L_2, of the step along the shock affects the size of the grid of characteristics. It is taken as 1/100 of the body length. The number of body points that will be calculated is approximately one half of the reciprocal of the factor, or 50. Knowing L_2, the location of N can be calculated, and the flow there can be obtained from Eq. (A2). Now an iteration to improve the value of ω is begun.

An approximate right characteristic is run back from N to Z, and the location of Z is calculated. The flow conditions at Z are obtained by an interpolation between S and R. A correction, Δ, to the shock angle is now assumed, and the corresponding changes in q and θ are set proportional to Δ. The corrected values are substituted into the compatibility equation between Z and N. Only Δ is unknown. The corrected value

for ω is found to be

$$\omega_{k+1} = \omega_k + \frac{q_Z - A_Z\theta_Z + B_Z/\sin(\bar{\theta}_Z + \bar{\mu}_Z) - C_Z - q_N + A_Z\theta_N}{q_2' - A_Z\delta'} \tag{5}$$

The derivatives q_2' and δ', with respect to ω, are evaluated numerically, using Eq. (A2) and the flow conditions ahead of N. The whole calculation is now started over, using the new value for the shock angle. It is iterated twice.

If the flow ahead of the shock is arbitrary, there will be previously calculated characteristics points ahead of the new segment of the shock. A fictitious point, F, is calculated by ignoring the shock (see Fig. 8). The new point is placed at the intersection of the extension of the shock and the upper fictitious characteristic line. The flow conditions ahead of the shock at N are found by interpolation between R and F. The remainder of the calculation proceeds as for the head shock.

Expansion Corner

An expansion occurs at an outside corner such as that shown in Fig. 9. Several left characteristic lines begin at the corner and form a fan outward. There will be several points with different machine addresses but the same geometrical location—the corner. The fictitious point F is calculated by the normal body point procedure. The corner check is made after F has been calculated. The body surface angle on each side of the corner is then calculated. The angle change at the corner is tested. If it is negative, an expansion corner calculation is used.

It is begun by interpolating between B and F to find the flow conditions just ahead of the corner. At the corner, the change in y is zero, and the entropy is constant so the compatibility equation reduces to $q_{k+1} = q_k - A_L(\Delta\theta)$, where the angle change $\Delta\theta$ is 1/10 the angle change at the corner and is therefore negative. Eleven points are obtained for the corner, including the interpolated value, and then the incomplete right characteristic is completed down to the body.

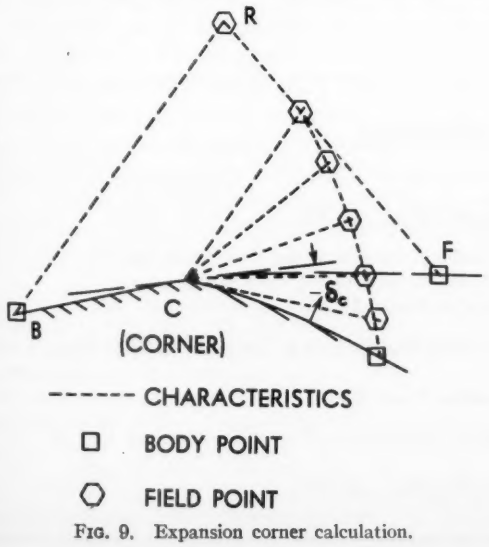


FIG. 9. Expansion corner calculation.

Shock Corner

If a corner is passed and the test indicates that the corner angle change is positive, a shock corner calculation is required. The flow properties ahead of the shock are found by an interpolation as for the expansion corner. The flow deflection given by Eq. (A2) must be equal to the corner angle change. The shock angle must be found by iteration. The overall iteration procedure described for the conical flow calculation can be used again. Eq. (A2) is used to calculate δ and $d\delta/d\omega$ for each assumed ω. The two programs are made to coincide by using the Mach angle just behind the shock as the criterion for a detached shock, and stopping the program, in this case also.

CONCLUSION

The use of the method of characteristics for routine calculation of supersonic flow around axial symmetric bodies has been outlined. Special attention has been given to the extensive logic required. The discussion provides a basis for planning a flow chart and the coding. If body-surface flow conditions are the desired output, the data for these points can be stored during the calculation and reduced to the desired form as a final step. The wave drag coefficient can be obtained in this phase; nonuniform integration steps must be handled, and provision for jumping across corners must be included. The grid size appears to be more critical as regards the drag-coefficient integration than for the accuracy of the flow properties themselves.

APPENDIX

The flow conditions at any point are related to q and S' by the following equations

$$\left.\begin{aligned} T &= 1 - g_2 q^2 \\ \sin\mu &= \sqrt{g_3 T/(1-T)} \\ p &= T^{g_4}\exp(-S'/R') \\ \rho &= p/T \end{aligned}\right\} \tag{A1}$$

Here T is the local temperature divided by the free-stream isentropic stagnation temperature, p is the local pressure divided by the free-stream isentropic stagnation pressure, and ρ is the local mass density divided by the free-stream isentropic stagnation mass density. The g's are functions of γ and are given below. The free-stream entropy S_∞' is zero.

The flow conditions behind a segment of an oblique shock inclined at the shock angle ω to the flow of Mach Number M_1 ahead of the shock are related to the flow ahead of the shock by the following equations:

$$\left.\begin{aligned}(q_2/q_1)^2 &= \cos^2\omega + \sin^2\omega\,(1 + g_3M_n^2)/(1 + g_5M_n^2)\\ \tan\delta &= \cot\omega(M_n^2 - 1)/(1 + g_5M_1^2 - M_n^2)\\ (S_2' - S_1')/R' &= g_7\ln(g_6M_n^2 - g_2) + g_4\ln(1 + g_3M_n^2) - g_4\ln(g_5M_n^2)\end{aligned}\right\} \quad (A2)$$

Here $M_n = M_1 \sin\omega$, and δ is the deflection angle caused by the shock. Conditions behind the shock are denoted by a subscript 2. The g's are functions of γ defined as follows:

$$\left.\begin{aligned} g_1 &= 1/\gamma R' & g_5 &= (\gamma + 1)/2\\ g_2 &= (\gamma - 1)/(\gamma + 1) & g_6 &= 2\gamma/(\gamma + 1)\\ g_3 &= (\gamma - 1)/2 & g_7 &= 1/(\gamma - 1)\\ g_4 &= \gamma/(\gamma - 1)\end{aligned}\right\} \quad (A3)$$

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Space Technology and the NACA *(Continued from page 34)*

creased, the first satellite was launched, followed soon by the second carrying the dog Laika. It is said that Laika had already been aloft on a rocket and been safely returned. Probably Sputnik II was the same type of rocket used in that work, now boosted into satellite orbit by large rockets from the ballistic missile program.

We need a similar step-by-step program, each step fully tested. I think there will be needed two parallel lines of vehicle development—one unmanned, which should be able to proceed rapidly, and the other man-carrying, whose development will probably be somewhat slower. I personally am unwilling to be a party to trying to put a brave young pioneer into orbit until his demonstrated chance of successful return is much better than 50 per cent. The earliest vehicles will be progressively larger unmanned satellites, carrying more and more complex equipment to perform more and more difficult scientific and engineering tasks. We may expect these to be followed by unmanned vehicles which travel around the moon, and later by those which land on it. This line of development has already attained its first objective.

Concurrently, there should be a systematic program on manned vehicles. The X-15 is a research tool to get some experience in flight into nearby space. Other projects should be initiated promptly toward the goal of manned satellite flight. As the chief milestones are passed, other—more advanced—goals should be set.

We have the talents and the resources to assure that we in America can lead the way. It is imperative, for the peace and welfare of the world, that we shall lead the way.

As I think about what lies ahead, I am reminded of the comment of Wilbur Wright voiced many years ago: "It is not necessary to look too far into the future; we see enough already to be certain that it will be magnificent."

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A discussion of the primary intelligence required in the case of stationary and moving targets and, in the latter category, the problems for aerodynamic and ballistic missiles.

Intelligence Sources for GUIDANCE

Arthur S. Locke
Vitro Corporation of America

THE WORD "intelligence," as applied in guided-missile parlance, may be defined as the ability to sense the interrelationships of the target and the missile in such a way as to guide the missile to the target. Implicit in this definition, then, is the fact that information, both as to the behavior of the missile and the location and behavior of the target, must be supplied to the missile guidance system. This paper will deal primarily with the intelligence which must be obtained from the target.

Basically there are two categories of targets: those which are moving and those which are stationary. Against moving targets, all guided missiles have in common the need that some portion of the guidance system shall observe, or sense, the target and its motion. The point of observation, where the intelligence is gathered, may vary; the target is conventionally sensed at the launching point or from the missile, but such observation may also be accomplished outside the missile, as for example, along the line of flight.

It is possible to sense a target—and determine its characteristics of behavior—by many means. A target may be seen; it may be audible. An aircraft or missile may emit radiated energy as heat. In these cases the observer plays a passive role; guidance systems employing such intelligence are called "passive."

Since a moving target is not cooperative by choice, the observer must be prepared to play a more active role. While he may illuminate an aircraft flying at night by means of a searchlight, this technique is obviously too limited. There is available, however, energy over the entire electromagnetic spectrum, from the ultraviolet to the long radio waves, which may be transmitted by the observer playing an active role and sensed by him as a reflection from the target. One major concern as to what part of the spectrum shall be employed for the intelligence source is the characteristic behavior of the transmitted energy in the medium through which it is propagated. If the medium absorbs the energy, then the range of usefulness is limited; if the energy is distorted, then the intelligence is unreliable; if the background emits at the same frequency, then the target cannot be accurately distinguished, and no usable intelligence is obtained.

Practical considerations govern the choice of the portion of the spectrum used for the intelligence source of a specific missile guidance system. These include the tactical use of the missile; its aerodynamic range; weight and space availability within the missile; air or surface launching; and other similar considerations. In general, advantages accrue to shorter wavelengths in the size, weight, and accuracy of the sensing equipment; conversely, the useful range of sensing equipment tends to increase with increasing wavelength.

In considering passive systems, let us simplify by discarding target-emitted sound as an intelligence source and consider only radiation emitted by virtue of target temperature. Such "thermal" radiation is distributed over the ultraviolet, the visible, and the infrared portions of the spectrum. The ultraviolet, consisting of radiation having wavelengths less than 0.4 micron, is relatively weak except from objects at very elevated temperatures and is therefore of minor importance for gathering intelligence for missile guidance. We shall omit visibility to the human as a guidance intelligence source, deferring to other than human detectors throughout the spectrum of 0.7 to 15 microns (micron $= 10^{-4}$ cm). The larger part of the radiated energy emitted by objects at ordinary temperatures lies within this region, although, as a matter of interest, it might be noted that the thermal radiation spectrum extends essentially to infinity and can be detected and measured at wavelengths of 1 or 2 cm.

The intensity of thermal radiation is a function of the emissivity and the temperature of the radiating body. Emissivity of an opaque material is a surface property. Any alteration, such as the roughening of a metallic surface, will change the emissivity of that surface. Polished metals are generally of low emissivity. Fig. 1

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The author wishes to thank the D. Van Nostrand Co., Inc., for permission to use Figs. 1–5 and 8 from "Principles of Guided Missile Design" (series), Grayson Merrill (Ed.), *Guidance* (volume), Arthur S. Locke, 1955; and the McGraw-Hill Book Co., Inc., for permission to use Figs. 6 and 7 from *Propagation of Short Radio Waves*, Donald Edwin Kerr, 1951.

shows the spectral distribution of energy for perfect emitters plotted against $J\lambda$, the emissive power of a unit area in the wavelength interval $\Delta\lambda$. These curves indicate the spectral distribution of radiated energy available for an intelligence source, if the target is a perfect emitter, and no atmosphere intervenes between the target and the detector.

The attenuation of radiation, in the infrared spectrum, by the earth's atmosphere is due to three processes: absorption by molecular constituents; scattering by haze, fog, or cloud particles; and scattering by air molecules. The physics of the processes of attenuation are here omitted for brevity, but the result of that attenuation for the infrared spectrum is shown by Fig. 2. Here are plotted the transmission spectra of the atmosphere, from approximately 0.4 to 14 microns. This curve presents the transmission spectrum of a 2,000-yard path containing a total of 17 mm. of precipitable water and atmospheric haze such that the transmission of red light of wavelength 0.61 micron is 60 per cent. Although such a day is quite hazy, it definitely is not foggy, and a large dark object might be seen against the horizon at about 8 nautical miles.

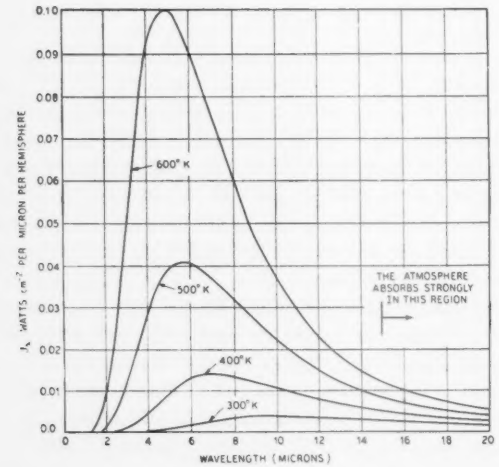
The "windows" in the atmosphere exist where the transmission coefficient is high; correspondingly, attenuation occurs at those wavelengths where the transmission coefficient is reduced to zero. No increase in the transparency of fog occurs in the infrared; a decrease in the attenuation by haze occurs at the longer wavelengths in this region. A decrease in the amount of precipitable water, from the 17 mm. shown, generally increases the transmission coefficients throughout, although not uniformly.

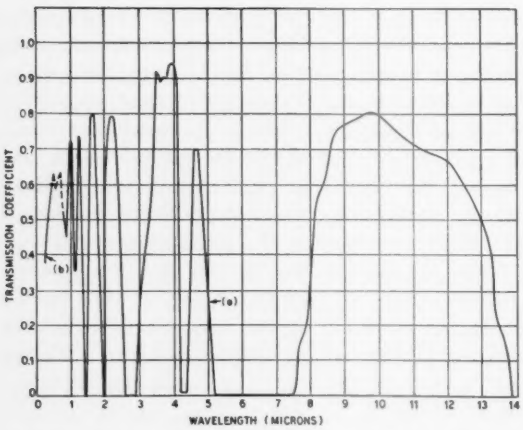
Attenuation at the shorter wavelengths is caused principally by water vapor (below 4 microns); at 4.27 microns lies one of the principal CO_2 absorption bands; water again attenuates in the 6-micron region. Ozone, O_3, when present, attenuates sharply at 9.5 microns, and CO_2 again is the strong attenuating agent around 14 microns.

Detection of the emitted thermal energy may be accomplished by several devices which serve to translate the energy received into electrical signals which may then be employed, by manipulation, in the guidance system. Fig. 3 shows three typical spectral response curves for photoconductive cells, two of lead sulphide, maintained at 293 and 90°K, and one of lead telluride at 90°K. These curves are relative, with the peak sensitivity of each arbitrarily set at unity. It does not follow that the cell which is sensitive over the widest wavelength range is the better for a given application, nor that the most sensitive cell is the best choice. Practical implications, such as cooling the cell, or availability must be considered.

If we combine the first three figures, we have Fig. 4. This rather formidable illustration shows the relative spectral intensity of a part of the 500°K. perfect emitter; the transmission curve of 17 mm. of water vapor; and the relative spectral response curves of the three photoconductive cells. If the product of these curves is integrated with a planimeter, Fig. 5 is obtained, showing the ratios of response to 500°K. radiation. Thus, if the several cells were of equal absolute sensitivity at the respective wavelengths of maximum response, the actual signal amplitude produced by cold lead telluride would be about 24 times that produced by lead sulfide at room temperature.

The most obvious application for intelligence derived from target heat radiation is that of a passive homing system. Such a guidance system might be expected to contain a parabolic reflector or other optical system for increasing the directivity of the system to the radiation





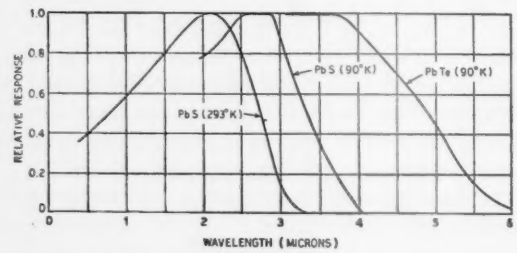


FIG. 1 (*top*). Spectral distribution of energy for perfect emitters.
FIG. 2 (*center*). Transmission spectra of the atmosphere.
FIG. 3 (*bottom*). Relative spectral response curves of *PbS* and *PbTe* photoconductive cells.

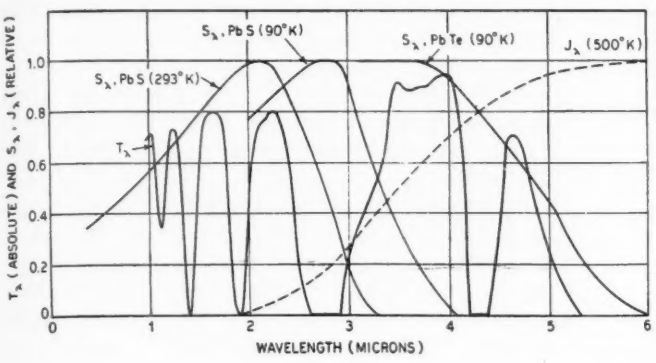


FIG. 4. J_λ for 500°K. source, S_λ for *PbS* and *PbTe*, and t_λ for 2,000 yards of atmosphere containing 17 mm. of precipitable water.

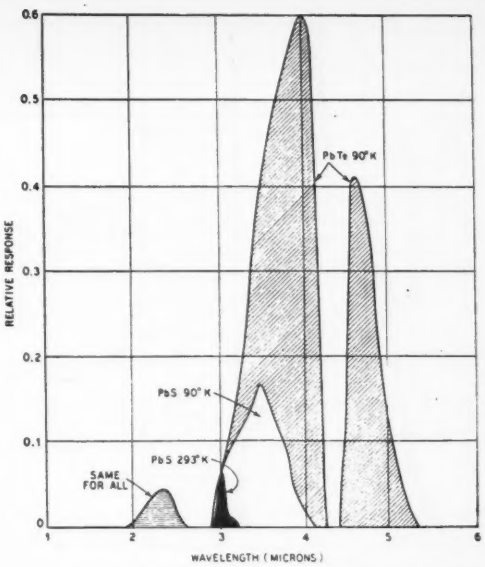


FIG. 5. The products J_λ, S_λ, t_λ, for *PbS* at 239°K. and 90°K., and *PbTe* at 90°K. for 500°K. source and 17 mm. of precipitable water.

intercepted. In any event, the effects of the use of the optical system must be superimposed on the intelligence gathering problem. In a homing missile it is also probable that an irdome must be provided to maintain the integrity of the missile. The characteristics of the material employed in the irdome must also be considered for shape, structure, and transmissive abilities.

Let us return to the situation of the moving target, wherein the observer plays an active role and transmits energy to sense, from the reflected signal, the target's position and behavior. This, of course, implies the use of a precision tracking radar, located either in the missile or elsewhere as part of the guidance system, to obtain guidance intelligence.

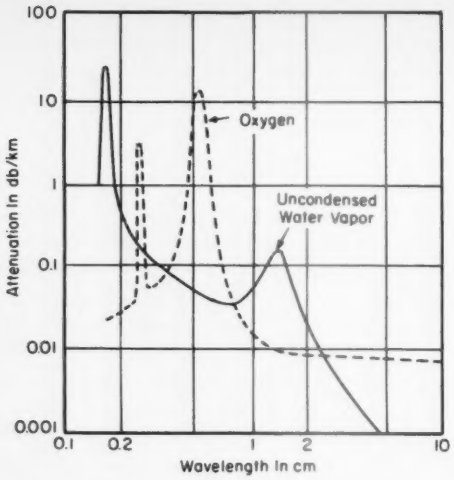
When the radar is located in the missile and both transmits and receives, the guidance system is called an active homing system. If the illuminating transmitter is located outside of the missile (as at the launching point) and the receiver only is in the missile, this is a semiactive homing system. If the target and missile tracking radars are located on the ground and the target and missile are both tracked, the missile is guided by commands—hence command guidance. Lastly, if a radar tracks the target and the missile rides the center of the radar beam by self-contained means, we have what is known as a beam rider.

Since the previous generalization that size, weight, and accuracy of the sensing equipment favor the use of shorter wavelengths still applies, the shorter radio wavelengths are of primary interest to the radar designer for the moving target. In general, precision tracking radar would be expected to use the superhigh-frequency radio band, having a wavelength range of from 1 to 10 cm. The final choice of frequency for the intelligence source is usually based on many factors, two of which are the availability of components and transmission characteristics.

In common with the infrared frequencies previously discussed, radio waves are attenuated in their passage through the atmosphere by absorption and scattering. Oxygen, water vapor molecules, precipitation in all its forms, and foreign matter such as dust all absorb or scatter radio wave energy. The atmosphere opens up to the transmission of radio waves only when the frequency becomes high compared with the rotational frequencies of the water molecule, which occurs in the infrared rather than the superhigh radio frequency region. Fig. 6 indicates the attenuation of radio waves in the superhigh and long infrared bands. As these curves are plotted, the spikes show attenuation rather than high transmission coefficients as previously illustrated in the infrared spectrum. The attenuating bands of oxygen and uncondensed water vapor are clearly shown, and equally clearly they indicate wavelengths to avoid. Theoretical attenuation by rain is shown on Fig. 7. Relative visibilities are also indicated.

When the observer employs an active role, he is free to employ methods which increase his ability to obtain target intelligence under inhibiting tactical conditions. A modern radar system is a complex collection of carriers and subcarriers and includes both amplitude and frequency modulation of them. Precision tracking radars are of many basic types. Principal among them are the pulsed radar, the continuous-wave Doppler radar, and the pulsed Doppler radar.

A pulsed radar gates the target in range; in other words, tracking intelligence is obtained from all echoes within the range gate. The range gate employs a target-velocity memory; when the target is in motion, increasing or decreasing the range, the time constant of the range rate mechanism is such that the gate continues momentarily to follow the target, even though it may be obscured by other objects at the same range. However,



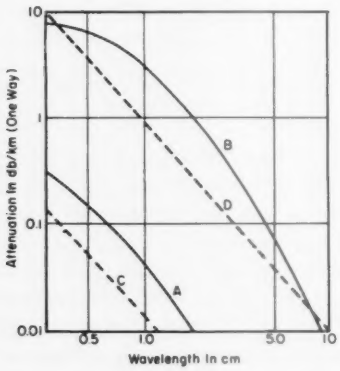


FIG. 6 (*top*). Theoretical values of atmosphere attenuation by oxygen and uncondensed water vapor at sea level for temperature of 20°C. in an atmosphere containing one per cent water molecules.

FIG. 7 (*bottom*). Theoretical values of attenuation by rain and fog. Solid curves show attenuation by rain of the following intensities: (A) Drizzle, 0.25 mm./hour and (B) Heavy rain, 16 mm./hour. Dashed curves show attenuation by fog or cloud of the following intensities: (C) Visibility, 2,000 ft. 0.032 g/m³ and (D) Visibility, 100 ft. 2.3 g/m³.

continued interference will degenerate tracking accuracy, or the target may be lost completely.

A continuous-wave Doppler radar gates the target as a function of velocity; in other words, tracking intelligence is obtained from all echoes moving at the same velocity. A moving target can therefore be isolated from large stationary targets but not from other targets moving at the same velocity. Range to target measurement is complex. A pulsed Doppler radar combines the range measuring ability of the pulsed radar with the clutter-rejection qualities of CW Doppler. On such a radar, the pulse delay is used to gate in range; however, only those echoes affected by Doppler shifts are allowed to actuate the tracking circuits.

The primary intelligence required in the case of stationary targets involves totally different considerations than those indicated in the previous discussion in connection with moving targets. In the interests of brevity, only surface-to-surface guided missiles of long range will be discussed. In such cases the target is usually large in size. The principal intelligence required is the accurate location of the target with respect to some standard reference such as the latitude and longitude, in terms of the earth's conventional reference. It is usually necessary to know accurately the location of the launching point in terms of the same reference. Two major subdivisions of guidance system problems exist: (1) that for aerodynamic missiles and (2) that for ballistic missiles.

An aerodynamic missile, despite the fact that it will fly at supersonic speeds, has a relatively long time of flight and may be considered amenable to guidance during the entire flight. A ballistic missile, on the other hand, has a short time for flight and is susceptible to guidance only during its propelled flight.

Let us first consider the aerodynamic missile. By reason of the long time of flight, the use of inertial devices as the sole means of guidance may be quickly discarded since errors in an inertial system tend to increase with time. Inertial systems may be used as the primary source of guidance if a means can be employed for monitoring the accuracy of the flight path, either continually or at discrete points along the path. In addition, the concept of employing homing terminal guidance may be considered.

To monitor a long-range flight, some form of navigation must be employed. The primary forms of navigation presently in use by aircraft and ships are adaptable as sources of missile guidance intelligence.

Historically, the earliest form of long-distance navigation is by use of knowledge of behavior of the planets or the stars. Theoretically, there is no difference in the concept of navigating an aerodynamic missile between two points on the earth's surface as compared to a conventional aircraft. In practice, the development of automatic sensing equipment for missiles to accomplish this task with the necessary accuracy is an extremely formidable one. Navigation under human guidance has always had the advantage that the navigator can see his destination during the last few miles of his voyage. However, for a guided missile to be sufficiently accurate, the navigation must be an order of accuracy better than the human navigator can usually accomplish. In the case of celestial navigation, intelligence as to present position of the guided missile is continually monitored by tracking stars automatically. This information is combined with the output of an adequate mechanical memory so that any deviation from the desired flight path may be computed and corrected.

Fig. 8 shows an inertial celestial guidance system and is employed as an example of how more than one type of guidance intelligence may be used in a single guidance system. The star trackers might employ a photoconductive cell for tracking the stars. The star trackers could be located on a stable platform fixed in space by means of inertial elements. The program track computer develops the present position of the missile; in turn, the position is compared in the computer with the desired missile trajectory. The vertical sensing unit is

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concerned continuously with the specific force and direction of gravity as the missile moves in its trajectory. The altimeter measures the height of the missile above the ground; the autopilot of the airframe employs inertial elements; lastly, a terminal guidance system might sense some unique characteristic of the target to guide the missile to it.

Another well-known means of navigation involves the use of radio navigation nets. There are many forms of such navigational nets disclosed in technical literature. Radio transmission in the medium- and high-frequency ranges is usually employed; the radio waves of these frequencies travel upward to the ionized layers of the atmosphere and are then refracted to the earth. Communication may be carried on across great distances with relatively small transmitting antennas and low transmitter power outputs. However, such transmission is affected by such factors as the time of day, season of the year, and meteorological conditions. In employing radio navigation for missile guidance, it is obvious that a system type which does not require radio response by the missile is more desirable than one in which the missile broadcasts its presence. Other means of obtaining guidance intelligence by earth references such as magnetic field, etc., are not sufficiently accurate for the purpose.

In the case of the ballistic missile, guidance is conventionally employed only during that portion of the missile's flight when propulsion forces are exerted. During this time the missile must be placed at a position on a proper trajectory, with the correct velocity vector, at the time of propellant burnout. The missile then travels along its trajectory unaffected by any forces other than those normally associated with the rotating earth and its planetary system—i.e., gravity, Coreolis, sun, moon, etc. At first glance, the most desirable form of guidance intelligence during the propelled phase of a ballistic missile is that derived from inertial mechanisms plus a convenient memory system. This permits a

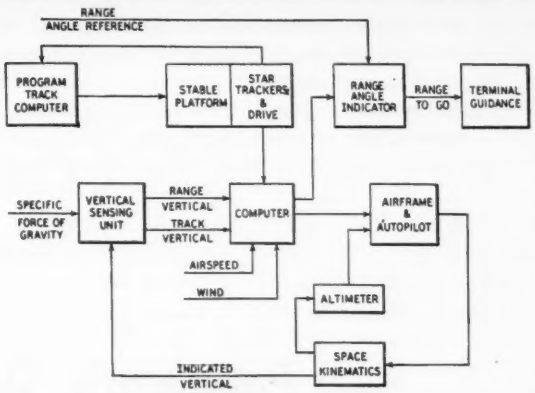

FIG. 8. Inertial celestial guidance system.

comparison between the actual flight path and the desired flight path so that any discrepancy may be corrected during the propelled flight. While this sounds easy to accomplish, equipping a ballistic missile with inertial devices of sufficient accuracy to accomplish its mission adequately is difficult indeed. The alternative to a purely inertial system for ballistic missiles is a combination of radio and inertial equipment. In this case, measurements by radio waves of the missile's trajectory during its propelled flight are made so that corrections during the flight may be imposed upon the inertial system.

In addition to the principal guidance intelligence sources mentioned individually in this discussion, we have illustrated that guidance systems almost invariably employ more than one intelligence source in combination with another. If we were to catalog all possible combinations, an extremely formidable list would result. It should be noted with interest that the majority of the possible combinations have been tried experimentally and that the most promising are now represented in missiles either in, or nearing, operational use.

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AERONAUTICAL ENGINEERING REVIEW

The following recommendations, based on experience with tension and compression types of duct systems on two different aircraft models, are offered for consideration:

Pneumatic systems should be placed in the same priority category as prime aircraft structure.

A tension system, because of its relative simplicity and lighter weight, is preferred over a compression system.

A specific set of duct and bracket design criteria should be established.

Pneumatic System Design

J. V. Dymkowski
Douglas Aircraft Company, Inc.

TURBOJET and turboprop aircraft engines afford a relatively inexpensive source of energy (compressor bleed air) for driving accessory equipment, cabin pressurization, air conditioning, and anti-icing. Bleed air is transported from its source to the various systems components by means of ducting systems. Ducting must be lightweight yet sturdy enough to contain air at a temperature of 800°F. and a pressure of 300 psig. The installation must be rigid and at the same time flexible enough to accommodate thermal growth, structural deflections, and component tolerance accumulation.

To compensate for the various motions, several types of flexible connector are included in the tension or compression type of ducting system. System integrity is assured by the utilization of varied permanent and removable duct connectors, and the complete system is supported by brackets of several basic types.

DESIGN CONSIDERATIONS (REQUIREMENTS)

Two basic aircraft models—one a twin-engine turbojet, the other a four-engine turboprop—presented a number of varying design considerations. Operating air pressure and temperature maximums of 230 psig and 750°F. were defined in engine performance curves. In order to contain and deliver air to the various systems, the following design considerations, which generally apply to all systems, had to be satisfied.

Safety

The safety of both the occupants and the aircraft is a prime item. A component failure (duct rupture) due to poor pneumatic system design may result in (1) personnel injury by exposure to extreme ambient temperatures or through the loss of pneumatically driven aircraft systems and (2) structural damage through overpressurization or overheating.

Mr. Dymkowski is an Air-Conditioning Engineer, Long Beach Division.

Weight

All aircraft component weight is considered a deterrent to overall aircraft potential. Growth factors of 10 for specific fighter-type aircraft and 5 for a transport type have been expressed. Therefore each item must be carefully considered from a weight aspect.

Motion

(1) Due to Thermal Growth—Duct systems must incorporate provisions to permit relative growth of approximately 0.1 in./ft. of duct length due to the temperature differential between duct and mating structure.

(2) Due to Structural Movement—A major portion of the pneumatic duct system is usually housed within the ever-flexing wing and fairing-type engine and landing-gear pods. Structural deflections in the order of 0.1 in./ft. of wing span and as great as 3/4 in. between fixed items within the pods are within the realm of possibility and must be considered.

Assembly

Variations in complex production assemblies make it necessary, in some cases, to allow for a linear adjustment of 5/8 in. in a 6-ft. span.

Replaceability

It is desirable to make possible the removal and interchanging of short duct sections for the purposes of inspection, access to other items in the area, and replacement in the event of duct damage.

Space

Duct routing is usually complicated because the available space must generally be shared with other systems. Fig. 1 presents a fine example of this point. The space available plays a major role in the final system type selection.

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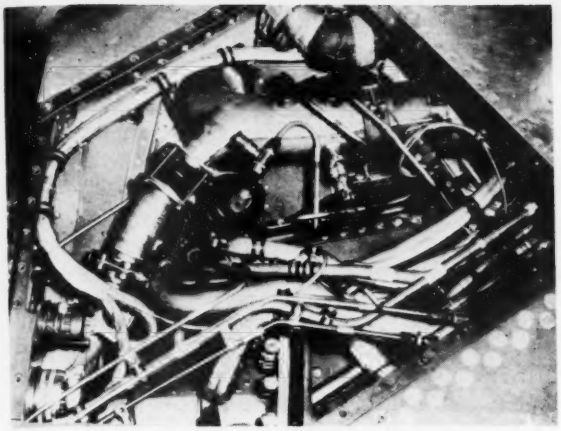


FIG. 1. Duct in congested area.

DUCT SYSTEM TYPES

In order to satisfy design considerations, the designer makes use of a tension- and/or compression-type duct system.

Tension

In the tension-type system, the ducting is held rigid with brackets at a given point and allowed to move or "float" away from this restraint. All other brackets are of the guide type and are designed to support the duct weight and to ensure duct travel in a specific preselected plane. Thermal growth is allowed by duct system growth, and bending is restricted to restrained flexible connectors of the ball or bellows type. The ducting is primarily subjected to tension loading since no compression load inducing restraints are employed. Therefore the pneumatic load is not transmitted into the structure. (See Fig. 2.)

Compression

The compression-type system is held rigid with brackets at the extreme ends. The ducting is not permitted to "float" but rather is maintained firmly to prevent squirming, binding, and/or excessive ball-joint leakage. The system is designed to transfer duct motion by compression of bellows or slip joints. Since all motion is directed toward the growth-absorbing unit, away from the fixed end supports, the ducts must be capable of withstanding pneumatic and thermal loads in compression. (See Fig. 3.)

The tension system is generally the lesser in weight; however, it requires more space for duct movement. Because of the limited load capabilities of the guide-type supports, a single failure may result in the failure of a large portion of the duct installation. The compression system, in addition to the pneumatic and thermal loads, must make provision for considerable side load. This, coupled with the inherent instability of the free bellows, requires the system to be more sturdy and thus imposes an important weight penalty. Because a compression system of any considerable length is composed of many short, self-contained systems or duct runs, a single component failure will not result in the loss of a considerable portion of the duct installation but rather will be confined to a specific short segment. The compression-type system requires a more precise analysis because of the magnitude of types and combinations of loads which may be encountered.

Systems Used by DAC LB

Initial experience with engine compressor bleed air systems came with the design of the twin-engine jet model. This aircraft is a typical high-performance model with maximum air temperatures and pressures of 750°F. and 230 psig. A minimum of space was available for the installation of the required 3 $^1/_2$-in. diameter ducting. The limited space consideration strongly influenced the final decision to install a compression-type system in this model. A major portion of the pneumatic system consists of 0.035-in. to 0.042-in. wall gage ducting. The ducting begins at the nacelle and is routed through the pylons and wing toward the fuselage where it is joined with the various systems components. All duct connecting flanges were of the flat-faced machined bolted type, with recessed grooves for O rings, both metallic and silastic, which were used for sealing. Newly developed ball and slip joints were installed to accommodate relative motion.

The four-engine turboprop model which followed evolved with both basic systems—a compression-type system in the wing which connects the four engines and tension-type systems in the fuselage and landing-gear pods where all the major system components were located. Bleed air limits of 110 psig pressure and 550° F. temperature were presented, and pneumatic ducts up to 7 in. in diameter, with the majority 5 in. in diameter, were established. Free bellows, ball joints, knuckle joints, and newly developed commercial sheet metal duct flanges and vee band couplers were designed into the prime air systems.

DUCT CONNECTORS (FLEXIBLE)

A large variety of duct connectors, both flexible and rigid, have been used to permit required movement and

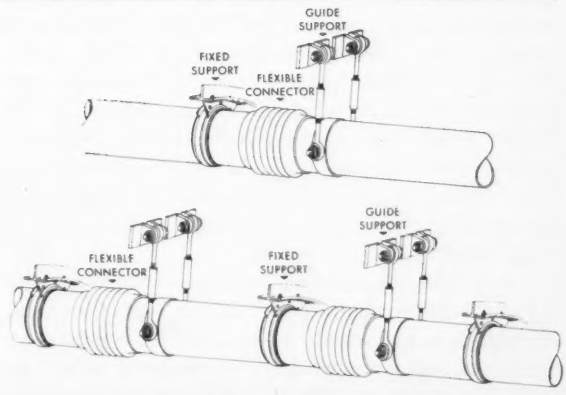


FIG. 2 (*top*). Tension-type system.
FIG. 3 (*bottom*). Compression-type system.

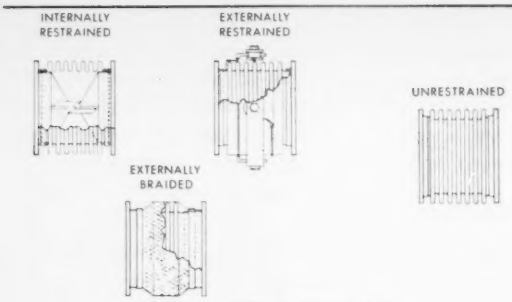


FIG. 4. Bellows connectors.

TABLE 1

SPECIMEN NO.	DEPTH OF CONVOLUTION	NUMBER OF PLIES	GAGE OF PLIES	BEFORE LIFE CYCLE TEST FORCE IN POUNDS REQUIRED FOR: 5 PERCENT EXTENSION	10 PERCENT EXTENSION	15 PERCENT COMPRESSION	.070 LATERAL OFFSET WITH ENDS PARALLEL	AFTER LIFE CYCLE TEST FORCE IN POUNDS REQUIRED FOR 5 PERCENT EXTENSION
1	1/2	2	.007-.010	FAILED DURING PROOF TEST				–
1A	5/16	2	.007-.010	78	178	198	88	84
2	1/2	3	.005-.007-.005	FAILED DURING PROOF TEST				–
2A	5/16	3	.005-.007-.005	47	96	106	83	40
3	1/2	3	.007-.005-.007	FAILED DURING PROOF TEST				–
3A	5/16	3	.007-.005-.007	78	147	146	102	59
4	1/2	3	3 OF .007	22	–	66	61	34
4A	5/16	3	3 OF .007	106	283	195	80	77
5	1/2	3	.007-.010-.007	28	56	92	152	33
5A	5/16	3	.007-.010-.007	129	227	256	197	99

ALL UNITS (EXCEPT AS NOTED) SUCCESSFULLY WITHSTOOD BOTH A 170-PSIG PROOF AND 255-PSIG BURST PRESSURES AT ELEVATED TEMPERATURES.

to maintain system integrity. This section deals with those with which we are most closely associated.

Bellows

Bellows can be placed into two general classes—free or unrestrained, and restrained. (See Fig. 4.)

Free or Unrestrained

A free unit is nothing more than a convoluted duct (Fig. 4), usually of multi-ply construction. It is relatively light and compact and therefore can be installed in a limited space.

Table 1 reflects data gathered from tests of several 5-in. ID bellows. The live length ($3^1/_2$ in.) and number of convolutions of each specimen were held constant.

The results of this program confirmed that bellows spring rate was not appreciably increased as a result of the life cycle test. In fact, it was demonstrated on several occasions that the force to affect motion was actually lower after the application of 5,000 cycles. Although no definite pattern of force to move vs. ply combination was detected, it was indicated that the bellows length and convolution height encourage instability which will result in squirming or system failure. This consideration requires substantial restraint provision for inline control which provides a major penalty of added weight to the aircraft.

It was also confirmed that this type of unit is capable of a total excursion equivalent to 25 per cent of the total convoluted or live length, 15 per cent for compression and 10 per cent for expansion. However, it should be noted that this is an extreme movement and should be avoided. A more acceptable maximum of 20 per cent of the total convoluted length, 15 per cent for compression and 5 per cent for expansion, is recommended.

As a result of this and other similar programs, the following limit capabilities, which have been successfully applied, were established.

Axial offset	0.02 in./in. of convoluted length
Angular deflection	5°
Ratio of convoluted length to unit diameter	1 to 1
Convolution height	3/8 to 1/2 in.
Compression	15 per cent of convoluted length
Expansion	5 per cent of convoluted length

It is emphasized that these limitations are rules of thumb, gathered from a limited number of tests which were necessary because of lack of manufacturer's design information for a specific application, and are by no means intended for universal usage. It is suggested that development tests be conducted to evaluate various designs for each specific set of design considerations.

From these and vendor development tests evolved a specific production item which is of two-ply construction, each ply 0.010 in. thick. Convolution height is 3/8 in.; 15 per cent compression and 5 per cent extension are affected for a reported force of 125 and 40 lbs. respectively, while a 0.070-in. offset with ends parallel requires an approximate force of 40 lbs.

Restrained (Braided)

Bellows of a multi-ply construction, the same as the free, incorporating some means of self containment are called restrained. Restraint is accomplished by any of several means, such as external metal braid (Fig. 4) or a knuckle type of mechanism which may be in the form of internal or external links, tie rods, or spherical bearings.

The braided type (probably one of the most popular) is the least desirable of the lot because bending under air pressure is extremely difficult. A $3^1/_2$-in. diameter unit of $3^5/_8$-in. overall length, under 200 psig pressure, required a moment in excess of 3,000 in.lbs. to effect bending of 3°. This condition is largely because the braid will not increase in length and bending must be accomplished by actually compressing one half of the bellows unit while holding the other half taut. This characteristic means that the braid must be of sufficient size to preclude failure under bending when approximately one half of the braid is required to carry the full load. In addition, unless the braid is uniformly attached, it will create local stress concentrations at points of contact with the bellows which will adversely affect the bellows life.

The braided bellows is as compact as the free bellows, but because it is self-restrained it is less susceptible to squirming. It is heavier but not more so than the weight of a free bellows and its associated restraining brackets.

Restrained (Knuckle)

Of the entire bellows family, the popularity and usage of the knuckle or tie rod type is on the increase. This

design offers self containment for about the same weight as a braided unit. The choice of an internal or external load carrying device is dependent on specific design considerations. The penalties are obvious. Internal ties impose a pressure drop increase, while an external linkage requires a greater space envelope and imposes an additional weight increase. In addition, this unit permits only bending motion since the restraining feature precludes linear movement. Tests on a knuckle joint of the same dimensional envelope and under identical test conditions as the braided unit mentioned earlier indicate that bending up to 5° could be accomplished with less than 560 in.lbs. moment.

Slip Joints

The prime purpose of a slip joint is to accept relative lineal duct changes. This unit is in reality a double-walled duct with a sealing member in between. The motion is, as the name implies, of the slip type. This unit permits relatively large motion within a reasonably compact envelope at a moderate weight penalty. Service to date on 3- and $3^1/_2$-in. diameter units designed to provide $1^1/_4$-in. total travel has been satisfactory. However, it is known that the concentricity of the seal, a metal reed type, is somewhat critical, and unit misalignment tends to either unseat or permanently damage the seal with a resulting increase in air leakage. Maximum leakage of 0.15 lb./min. is acceptable for a $3^1/_2$-in. diameter unit under all pressure conditions up to 230 psig. This unit, because of the pneumatic loading and concentricity demanded, must be contained in a manner identical to that used with unrestrained bellows. (See Fig. 5.)

Ball Joints

A ball joint is capable of a rotational and bending motion, but it does not permit lineal travel. An expenditure of several thousand man-hours has been devoted to the search for a satisfactory 5-in. diameter unit capable of ±10° bending and 360° rotation at less than a 70 ft.lbs. moment, and 5,000 functional cycles while under any combination of pressures and temperatures from 1/2 to 110 psig and −65° to 550°F. Since it is thought that a complete review of the overall ball joint program should in itself be the subject of a separate presentation, only a brief review will be made here.

During the past 3 years, more than 70 different test units—the efforts of some ten manufacturers—have been evaluated. The units thus far compared fit into two basic classifications, internally supported or without internal support. All of the units shown in Fig. 6 under classification 1 employ a central load carrying spherical bearing and weigh approximately the same (about 6 lbs.). Designs la and lb differ from 1c in sealing principle design. Design lb differs further from the other two in that it includes an additional set of ball bearings to further ease motion.

The designs under 2 are common only by reason of the fact that a central support is not used. Design 2a utilizes a metal seal and is dependent on metal-on-metal rubbing or sliding for motion, while 2b makes use of a nonmetallic seal and includes two different sets of bearings.

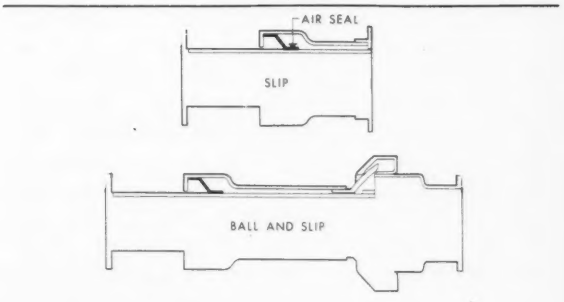
Although 2a is the most compact of the group, it is the most difficult to move. Conversely, 2b presents the largest overall diameter (8 in.) and is the heaviest of the group (about 8 lbs.), but it is the easiest to move. Motion of all units, except 2a, can be accomplished with less than the mentioned 70 ft.lbs. The breakaway or initial force required to effect motion is usually higher than the force required to continue motion. This principle is directly opposite to that associated with a knuckle joint where the force increases as does the angle of bending.

The "life" of the spherical bearing is limited, and failure of it will result in a system failure since this type is not self contained as are the units under 2. In addition, metallic or reed seal concentricity is important. Centrally supported units impose a pressure penalty which the units under 2 do not.

To date a completely satisfactory unit has not been found.

Ball and Slip Joint

A ball and slip joint offers all of the types of motion thus far mentioned in one relatively compact package. This arrangement affords a weight-saving since attaching flanges, clamps, or bolts are eliminated by welding together the ball and slip units. This method also eliminates a possible source of air leakage at the connecting point. Since this unit is nothing more than a marriage of a ball and slip unit, all of the comments under these units apply. (See Fig. 5.)



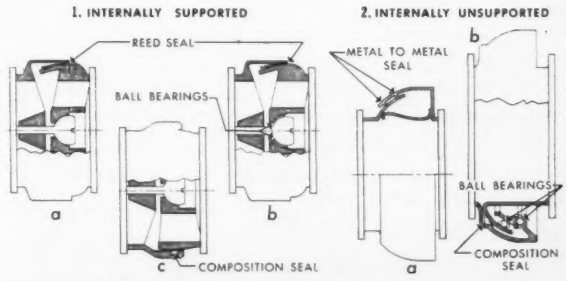


FIG. 5 (*top*). Ball and slip connectors.
FIG. 6 (*bottom*). Ball connectors.

Other Flexible Connectors

Omegas, loops, and Z bends are the simplest of all motion-compensating units but require considerable space, which is normally at a premium.

A minimum of test data and no service experience is at hand on the compensating joint shown. This unit requires considerable space, and visual inspection of one of the bellows components is not possible. This unit does reduce bracket requirements. (See Fig. 7.)

New Developments

For some time, manufacturers of flexible duct connectors have been encouraged to investigate the possibility of designing a knuckle joint with a rotating end. Such a unit could fulfill all of the requirements thus far established for a ball joint and could probably be produced in a more compact envelope. It is expected that a desirable weight-saving would also be effected. Achieving a satisfactory seal at the rotating mechanism is the one major obstacle which must be overcome.

Rigid Duct Connectors

Permanent

Several permanent duct connections (splices) are used; Fig. 8 defines the basic combinations.

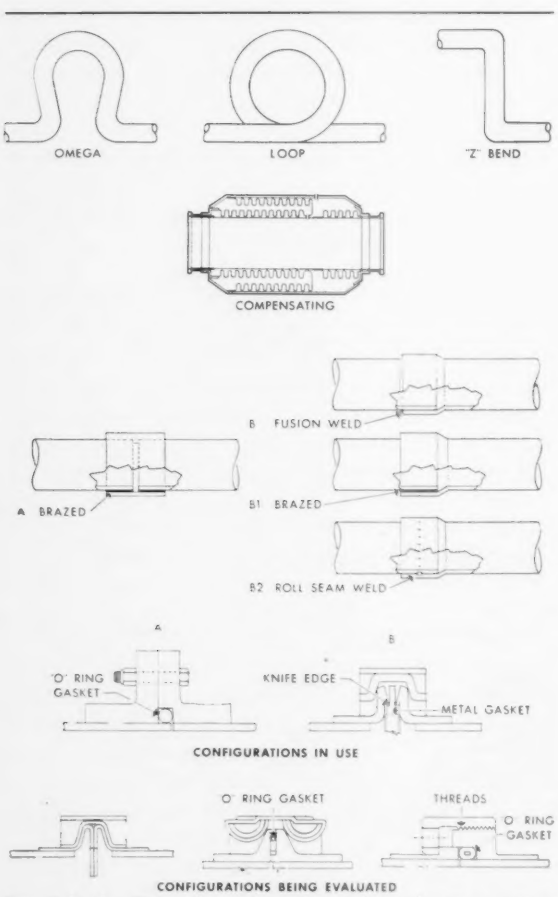


Fig. 7 (*top*). Expansion units. Fig. 8 (*center*). Duct splices. Fig. 9 (*bottom*). Duct connectors.

In service, the separation of a type B1 splice led to a thorough study and reappraisal of all brazed joints. The tolerance requirements for proper braze penetration were found to be so rigid as to require laboratory controls which obviously could not be accomplished in a production-line type of operation. Subsequent burst tests substantiated this theory since the results were erratic. All brazed ducts were immediately reworked, and brazed pneumatic duct splices were outlawed for all new designs.

Since the bulk of the data on duct splices is analytical in nature, an extensive test program designed to furnish bending fatigue strength data is now under way. Some 59 specimens are presently scheduled for this program.

Removable

The various types of duct connectors (Fig. 9, types A and B) used to date could stand improvement. Type A is cumbersome, heavy, and requires the installation of several time-consuming nuts and bolts. Type B is heavy and demands a high nut torque for proper assembly; it does incorporate a major advantage over type A since only one nut must be tightened. Both types include gaskets for seals which can easily be misinstalled. Both also demand unreasonable exactness of alignment.

An industry-wide search for a more efficient combination is now in progress. Some six different connector manufacturers profess to have designs which surpass those now in use (some of these are schematically shown in Fig. 9 under type C). These manufacturers have been requested to furnish specific test, assembly, and installation data which were outlined in a preliminary data request questionnaire. In addition, supplemental evaluation comparison tests are being conducted at DAC.

Some of the gains which are envisioned are (1) weight reduction; (2) easier installation due to gasket elimination, less critical alignment requirements, and lower nut torque requirements; and (3) incorporation of a safety lock or catch which will prevent duct separation in the event of a bolt or nut failure.

Design Criteria

Substantiation by test of currently used design criteria is being pursued. Available experimental evidence on life or endurance of duct systems is meager. Therefore the present criteria must include high margins of safety. The design criteria for ducts and brackets are influenced by (1) the dire consequences possible in the event of a failure, (2) lack of test data, (3) inconsistencies in manufactured parts, (4) operation at elevated temperatures, and (5) the variety and combinations of loads which may be encountered. Part of the criteria used in the pneumatic duct system design is as follows:

Ducts

Material yield stress is compared with the combined stresses due to:

(1) Two times operating pressure.
(2) Deflection due to operating temperature.
(3) Limit deflection of basic structure.

Material ultimate stress is compared with the combined stress due to:

(1) Four times operating pressure.
(2) 150 per cent deflection due to operating temperature.
(3) Ultimate deflection of basic structure.

Duct assemblies directly connected with high bending moment flexible joints are subjected to more stringent criteria in respect to deflection.

Supports

The maximum combination of loads due to pressure, thermal growth, and aircraft deflections is multiplied by a factor of one and one half, and the resulting stresses in the brackets are to be less than yield or two thirds of the allowable crippling stress, depending on which is applicable. This criterion is applied to steel brackets which comprise the majority of the brackets used. For aluminum brackets, the pressure load is multiplied by 2.25 and the resulting stress is to be less than ultimate or allowable crippling stress. The minimum load for any bracket is 200 lbs.

Assembly

Means of lessening manufacturing assembly problems associated with tolerance build-up during pneumatic system component installation should be considered in design. This criterion is satisfied by allowing as much as 30 per cent of the design motion of the flexible connectors for this purpose. In addition, several forms of bracket adjustment are normally included.

Tests

A variety of tests is necessary to ensure a successful design. Some of our test practices and major test programs follow.

In order to ensure a satisfactory level of duct quality in production, each duct assembly is subjected to a pressure twice the maximum operating pressure expected at ambient temperature. In addition, each aircraft installation is proof pressure tested at $1^1/_3$ times the maximum operating pressure and at elevated temperature.

A burst test at elevated temperature on each pneumatic duct component is conducted on the thinnest of three chosen at random from each first production lot fabricated. As expected, failures at below the design burst pressures of four times maximum operating pressure were experienced. Several formed parts in which the reduction in material thickness was as much as 50 per cent proved unpredictable. However, for a given configuration the material thickness variation was found consistent, thus allowing reinforcement of the thinned out regions. The survey established the critical areas to exist in the flat portions of duct intersections such as wyes and tees and at the crotch of intersections near the weld line. Addition of doublers in the critical areas ensured satisfactory compliance with burst pressure requirements.

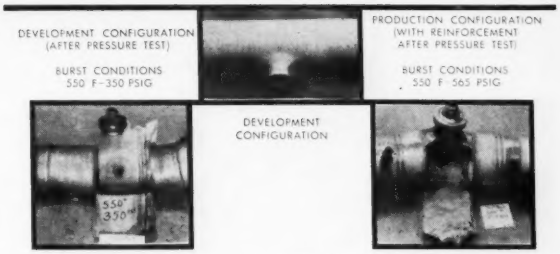


Fig. 10. Pneumatic duct development cycle.

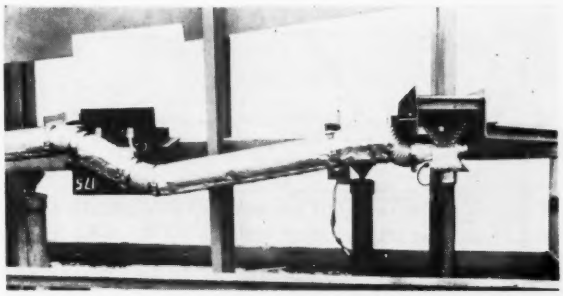


Fig. 11. Pneumatic duct system failure.

Fig. 10 demonstrates the complete cycle (before burst test, after burst test, and final reinforced configuration) of one of the configurations mentioned.

A complete mock-up of the wing pneumatic system was tested under conditions of limit wing deflection, one and one half times maximum operating pressure, and at maximum operating temperature. During the initial phase of the test, failures at test pressures just below the target pressure mentioned (similar to the one shown in Fig. 11) were sustained. The ducts are in compression because of duct growth from heat and the end loads produced by the convolutions in the free bellows. The system as shown was essentially a column with several pin joints. Rotation of the anchor bracket due to end load caused axial misalignment and subsequent bellows squirming and collapse of the duct. Additional failures were incurred because other supports allowed rotation of the nacelle "tee." Successful completion of the test was made possible primarily by adding "tee" duct stabilizing supports and widening the wheel base of the anchor bracket.

The life of the pneumatic duct installation was attested by a fatigue test of a representative portion (approximately 1/4 of the wing pneumatic ducting) of the wing pneumatic system. This portion of the duct system was subjected to cyclic loading in which temperature, pressure, and deflection were cycled. A total of 15,000 deflections to wing limit deflection, 7,500 thermal cycles from −45° to 550°F., and 7,500 pressure cycles from 10 to 110 psig have been imposed on this test section which was maintained in an ambient of −65°F. without failure.

(*Continued on page 66*)

"The approach described in this paper is based on the use of a single pressure-type probe that provides a direct sampling of the local (airframe-distorted) air stream."

A Philosophy of Air-Data Measurement

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SYMBOLS

H = free-stream total pressure, or, at supersonic speeds, the total pressure behind a normal shock, pounds per foot²
H_i = total pressure indicated by the probe, pounds per foot²
M = free-stream Mach Number
M_i = Mach Number indicated by the probe (uncorrected)
p_s = free-stream static pressure, pounds per foot²
p_i = static pressure indicated by the pitot-static probe, pounds per foot²
q_c = free-stream impact pressure, pounds per foot²
q_i = impact pressure indicated by the probe, pounds per foot²
$\bar{v}$ = free-stream velocity vector
α = free-stream angle of attack, the angle between the fuselage reference line and the free-stream velocity vector measured in the XZ plane, degrees
α_i = angle of attack indicated by the probe $[= (\Delta P_\alpha/q_i)f(M)]$, degrees
α_L = local angle of attack, degrees
β = free-stream angle of sideslip, the angle between the fuselage reference line and free-stream velocity vector measured in the XY plane, degrees
β_i = angle of sideslip indicated by the probe, degrees
β_L = local angle of sideslip, degrees
ζ = angle between the fuselage reference line and the free-stream velocity vector
ΔP_α = pressure differential between the upper and lower orifices on the probe hemispherical head, pounds per foot²
ΔP_β = pressure differential between the left and right orifices on the probe hemispherical head, pounds per foot²
$\frac{\Delta P_\alpha}{\alpha q_i}$ = the probe sensitivity $= f_1(M)$

THE SUCCESS of an airplane or an air-breathing missile in accomplishing its operational mission strongly depends upon the accuracy with which certain aerodynamic parameters of the air mass through which the airplane is flying can be measured. These parameters, collectively referred to as air data, include static pressure, total pressure, ang'e of attack, angle of sideslip, and total temperature (this last parameter is not considered in this paper). From these quantities other relevant information may be derived. The in-flight determination of the free-stream values of these basic parameters is difficult because of errors introduced by:

(1) the geometry of the sensing element(s)
(2) the pressure field and flow field around the airplane
(3) transducer response limitations (dynamic and static)
(4) the computing and indicating system

Increases in the altitude and speed ranges of modern aircraft have made air-data measurements and calibration correspondingly more difficult.

There are various possible methods of accomplishing the measurement of the aerodynamic parameters cited above. The approach described in this paper is based on the use of a single pressure-type probe that provides a direct sampling of the local (airframe-distorted) air stream. The probe-measured values of the local static pressure, local total pressure, local angle of attack, and local angle of sideslip are corrected by a computer to free-stream values. The functional relationships between local and free-stream values of the various parameters are determined from full-scale flight-test data augmented by data from wind-tunnel tests.

This paper presents a summary of work in air-data measurements conducted at the Cornell Aeronautical Laboratory under sponsorship of the U.S. Navy Bureau of Aeronautics. This effort has included the design and development of air-data sensors, pressure transducers, and airborne computers, as well as full-scale flight tests and wind-tunnel calibration tests. A theoretical method for determining airframe position errors was also developed.

THE BASIC SYSTEM

Measurement of the basic parameters of static pressure, total pressure, angle of attack, and angle of sideslip, is based on the following concepts:

This paper was presented at the U.S. Navy Bureau of Aeronautics Symposium on Air Data, Cornell Aeronautical Laboratory, Inc., September 24–26, 1957.

The authors are Principal Physicists in the Applied Physics Department.

(1) Direct sampling of the local air stream.

(2) Use of a single, fixed, pressure-type probe with no external moving parts to provide a simultaneous measurement of a set of pressures.

(3) Acceptance and calibration of: (a) probe measurement errors and (b) position-errors at the airframe location selected for the probe; these errors are determined from full-scale flight-test calibrations supplemented by wind-tunnel tests and theoretical analyses.

(4) Selection of a probe airframe location which minimizes position-error magnitudes and interactions.

(5) Use of a computer to simultaneously compute and apply position-error and cross-coupling corrections to the probe-sampled pressure data.

This probe senses total and static pressures and a set of differential pressures which permit values of local angle of attack and sideslip to be determined. The total head and static orifice configurations shown in Fig. 1 are not the optimum design for insensitivity of these probe-measured pressures to flow inclination. For example, the relatively small size of the total head orifice with respect to the probe diameter and the circumferential arrangement of the static orifices cause these measured pressures to be more sensitive to angle of attack than other well-known orifice configurations. However, since position-error corrections have to be made to the probe-sensed pressures, certain probe limitations are accepted in exchange for other desirable features of a compromise design. The use of a smaller-than-optimum total head orifice diameter permits this single probe to measure the four pressures H_i, p_i, ΔP_α, and ΔP_β, as shown in Fig. 1. (If desired, the diameter of the total head orifice could be enlarged within reasonable limits.) The hemispherical nose shape provides a high sensitivity and linear response (at a given Mach Number) for measurement of flow angle. The blunt nose is also favorable from the standpoint of anti-icing since the heater element can be located in close proximity to the forward surfaces of the probe.

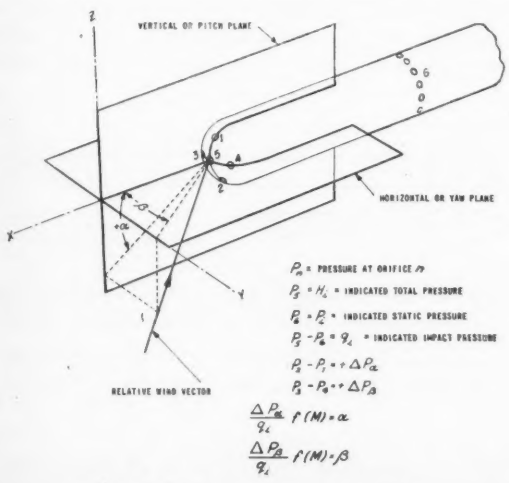
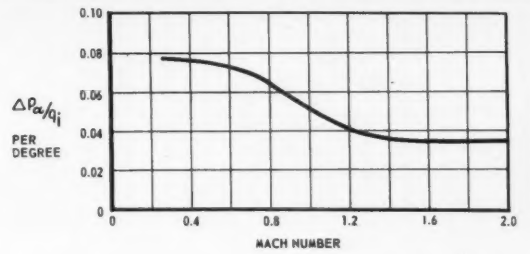

VERTICAL OR PITCH PLANE
HORIZONTAL OR YAW PLANE
RELATIVE WIND VECTOR
P_o = PRESSURE AT ORIFICE n
$P_2 = H_c$ = INDICATED TOTAL PRESSURE
$P_4 = P_s$ = INDICATED STATIC PRESSURE
$P_3 - P_s = q_c$ = INDICATED IMPACT PRESSURE
$P_1 - P_s = +\Delta P_\alpha$
$P_5 - P_s = +\Delta P_\beta$
$\frac{\Delta P_\alpha}{q_c} = f(M) = \alpha$
$\frac{\Delta P_\beta}{q_c} = f(M) = \beta$

FIG. 1. The yaw-pitch pitot-static probe.



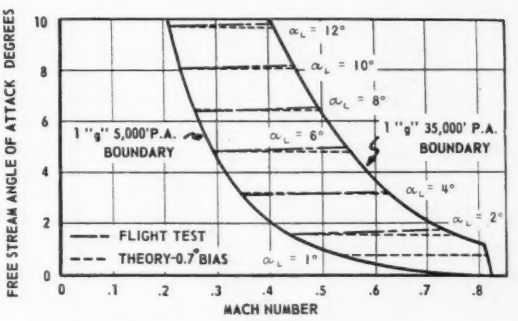


FIG. 2 (*top*). Sensitivity of the C.A.L. probe as a function of Mach Number.

FIG. 3 (*bottom*). Comparison of theoretical and experimental angle of attack position error (F9F-2 aircraft).

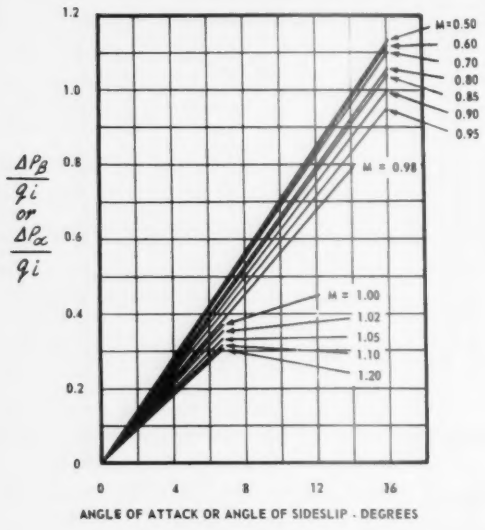
The static orifice arrangement, in the form of a single ring of twelve evenly spaced orifices, has been employed to obtain identical probe performance characteristics in static pressure measurement with variation of angle of sideslip and angle of attack. For applications where the sideslip angle is maintained close to a zero value, as for aircraft employing yaw dampers, other orifice arrangements insensitive to angle of attack effects are recommended.[11–15]

Fig. 1 indicates also that the sensitivity $\Delta P_\alpha/\alpha q_i$, used in the determination of airflow angles from probe differential pressures, is a function of Mach Number; Fig. 2 illustrates the variation of this sensitivity with Mach Number. The function is a smooth curve with a high-speed ($M \cong 2$) value of sensitivity approximately one-half of the maximum low-speed figure. The pressure ratio $\Delta P/q_i$ is linear with angle of attack at any one Mach Number. Although no wind-tunnel data have been taken at C.A.L. on this probe beyond Mach 2.0, other relevant data indicate that useful performance may be expected up to speeds where thermal stresses on the probe would be the limiting factor.

THE PROBE-AIRPLANE CONFIGURATION

Air-data measurement requires that the combination of the airframe and the attached probe be considered as the sensor. Significant simplification of the sensor-computer system is achieved by selecting a probe location which results in low values of position error. As the result of extensive flight tests,[2] a location forward of the fuselage nose was selected as the favorable location for the yaw-pitch pitot-static probe.

FIG. 4. Nose boom installation (F9F-2 aircraft).



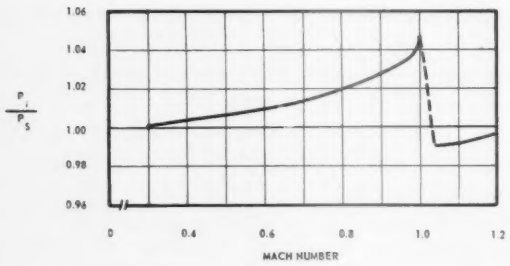


FIG. 5 (*top*). Wind-tunnel calibration data (corrected for tunnel and probe misalignments).

FIG. 6 (*bottom*). P_i/P_S vs. Mach Number, 1/4-scale probe on 1/4-scale fuselage delta wing model.

The fuselage nose location offers many advantages for an air-data sensing probe. The sharp-nosed, high-fineness ratio bodies of current aircraft give rise to well-defined and relatively small position errors even for short—e.g., 2 to 3 ft.—nose booms. These airframe position errors are primarily the result of body thickness effects since the wings are located well aft resulting in upwash effects at the probe location that are generally negligible. An insensitivity to induced flow effects resulting from roll maneuvers of the aircraft is realized for an axial position of the probe, although induced angle of attack errors are produced by pitching. These latter effects can be corrected by use of data from a pitch rate gyro.

For regularly-shaped fuselages, typified by bodies of revolution or three-axis ellipsoids, analytical techniques were developed[6] for predicting the local subsonic flow field to a high degree of accuracy. These techniques can be used to reduce effectively the expensive and difficult flight calibration time required for determining position errors.

A very important performance characteristic of a nose-boom probe employed for air data is realized at supersonic speeds. At Mach Numbers larger than that at which the fuselage bow wave passes aft of the probe static orifices—e.g., $M \cong 1.02$—there are no airframe position-error effects on the probe since pressure disturbances cannot propagate ahead of a shock wave in a free stream. Thus, to obtain free-stream pressure data at supersonic speeds, only the characteristics of the probe require compensation. These probe characteristics can be obtained directly by wind-tunnel calibrations, and, therefore, expensive and difficult full-scale supersonic flight calibration is not required. Airframe position errors need to be calibrated only in the subsonic and transonic speed ranges.

Flight-Test and Wind-Tunnel Calibration Data

As stated earlier, the program has included full-scale flight testing up to a Mach Number of 0.8; subsonic, transonic, and supersonic wind-tunnel calibration; and the development of theory for determination of position errors at subsonic speeds. Fig. 3 demonstrates the small value of the angle of attack position

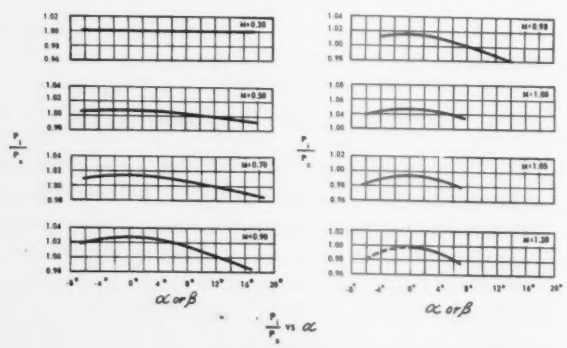


FIG. 7.

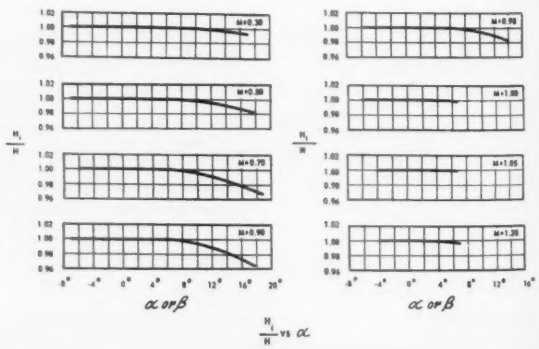


FIG. 8.

error, $\Delta\alpha$, that was obtained for a short-boom installation on an F9F-2 aircraft. The position error, $\Delta\alpha$, $\alpha_L - \alpha$, is the difference between the local angle of attack sensed by the probe and the free-stream value for the angle of attack and was experimentally determined to be about 0.2α. Fig. 3 also shows the excellent agreement between the flight-test data and the corresponding theoretically predicted values (corrected by a 0.7° bias).

Flight calibrations of angle of attack were made in the steady-state 1g condition wherein the aircraft was stabilized in altitude and air speed, and the angle of attack by reference to an accurate vertical.[8] Whenever perfect stabilization was not attained, corrections were made for aircraft flight-path angle from a time history of air speed and altimeter readings. By flying over the Mach Number range of the aircraft at various altitudes, angle of attack and Mach Number effects were determined.

Experimental models of air-data computers were developed and successfully flight-tested for F7F and F9F-2 Navy fighter-type aircraft. These computers provided values for free-stream angle of attack, angle of sideslip, Mach Number, relative air density, true air speed, and free-air temperature. A total temperature probe provided a temperature input to the computer. Nose boom installations were employed on both aircraft; the probe head was 36 in. forward of the fuselage nose of the F7F and 18 in. ahead of the nose of the F9F-2 (Fig. 4). The F9F-2 probe installation was made approximately 7 in. above the fuselage reference line to demonstrate the operational feasibility of boom locations other than axial.

To evaluate the applicability of the yaw-pitch pitot-static probe as an air-data sensor in the transonic region, wind-tunnel tests[10] were conducted up to a Mach Number of 1.2 on a 1/21-scale F11F aircraft model with a nose-mounted probe. The results[10] demonstrated that the probe-sensed pressures could be related to the corresponding free-stream values by functions sufficiently well behaved to be instrumented by current computer techniques.

Additional wind-tunnel studies were completed recently on a 1/4-scale probe-fuselage delta-wing model. The configuration tested closely duplicates the shape of current supersonic aircraft. The object of these tests was to obtain position-error data for the axial nose location of the yaw-pitch pitot-static probe in the Mach Number range from 0.3 to 1.20. The configuration calibrated corresponded to a full-scale boom length of 21 inches.

Probe performance data in angle of attack or sideslip are shown in Fig. 5. The probe response is linear at any fixed Mach Number and the sensitivity decreases with increasing Mach Number.

Probe performance data in the measurement of static pressure are shown in Figs. 6 and 7. Fig. 6 shows the ratio of indicated static pressure to free-stream static pressure, P_i/P_s, as a function of Mach Number for $\alpha = \beta = 0°$. Fig. 7 shows the effect of α or β on probe static pressure performance over the Mach Number range tested. The static pressure data show a sensitivity to angle of attack, angle of sideslip, and Mach Number. Precise computation of the free-stream static pressure based on indicated or local static pressure therefore requires inputs of the free-stream Mach Number and the free-stream angles of attack and sideslip.

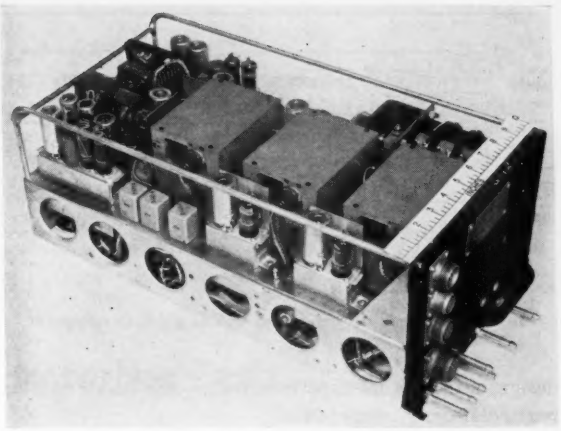


FIG. 9. Air-data computer, experimental model for F9F-2.

Probe performance data in the measurement of the total head pressure are shown in Fig. 8. Total head measurements are affected only by flow angle inclination and are essentially independent of Mach Number effects.

THE COMPUTING SYSTEM

Fig. 9 is a photograph of an experimental model of an air-data computer designed for use in F9F-2-type aircraft. The computer, fabricated and flight tested in 1953, weighed about 35 lbs.

On the basis of the transonic wind-tunnel calibrations of the yaw-pitch pitot-static probe on the 1/21-scale F11F model and on the 1/4-scale fuselage delta-wing combination, indicated* and free-stream values of α, β, H, p_s, and q_c can be related as follows:

$$\alpha = \alpha_i f_\alpha(M)$$

$$\beta = \beta_i f_\beta(M)$$

$$H = H_i f_H(\alpha, \beta) = H_i f_H'(\zeta)$$

$$p_s = p_i f_p(M, \alpha, \beta) = p_i f_p'(M, \zeta)$$

$$q_c = q_i f_q(M, \alpha, \beta) = q_i f_q'(M, \zeta)$$

A block diagram of a computer proposed to perform the air-data computations indicated above is shown in Fig. 10. Computations are based on impact pressure, q_c, rather than total head pressure, H, although the latter could also be used. In the diagram of Fig. 10, the q_c and P_s compensators would need to be three-dimensional cams or suitable electrical analogs. Using wind-tunnel test data, it was ascertained that standard computer techniques would suffice to implement this

* Indicated values are designated by the subscript i.

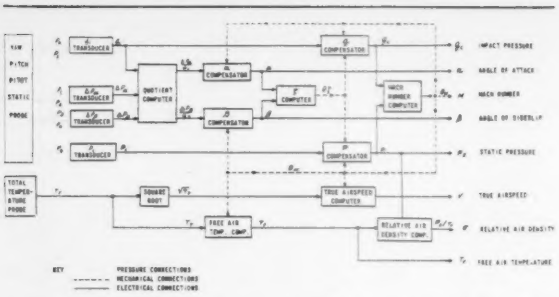


FIG. 10. Typical block diagram C.A.L. air-data computer.

design, although no experimental models based on this particular design were built.

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XUM

Small samples of a gasoline stock, kerosene, stove oil, and typical JP-3, JP-4, and JP-5 jet fuels were exposed to gamma radiation. Postirradiation tests were performed and these results compared with those from the original fuels. Gas evolution as a result of irradiation was also measured. The results obtained are compared for the various types of fuels.

A Survey of the Radiation Stability of Hydrocarbon Fuels

J. G. Carroll, R. O. Bolt, and J. A. Bert
California Research Corporation

A SURVEY was undertaken in 1953 to determine the effects of nuclear radiation on types of hydrocarbons currently used in aircraft engines. The scope of the program is outlined in Table 1. The fuels ranged in aromatic content from 4 to 28 per cent.

Two series of irradiations were made: one in the Canal Gamma Source of the Materials Testing Reactor (MTR) in Idaho and one in the MTR itself. In the first series, the damaging radiation consisted solely of gamma rays. In the second series, damage resulted from both neutrons and gamma rays.

Twelve milliliters of each fuel were irradiated in the Canal Gamma Source. An atmosphere of helium was provided over each sample, which was contained in a capsule[1] made from 410 stainless steel, as shown in Fig. 1. The gamma radiation was monitored by techniques described in the literature.[2–4] Gamma exposures are most frequently expressed in terms of the roentgen (r), which may be considered as a quantity of absorbed gamma radiation equivalent to 83.8 ergs/gram of dry air. One B.t.u./lb. corresponds to 2.75×10^5 r.

A smaller number of exposures in similar capsules were conducted in the nuclear reactor. The radiation present was expressed in terms of the slow neutron component, which was easily measured by known methods.[5] The fast neutron and gamma ray components, more difficult to measure, occurred approximately in direct proportion to the slow neutrons.[6]

Physical properties of the fuel samples were meas-

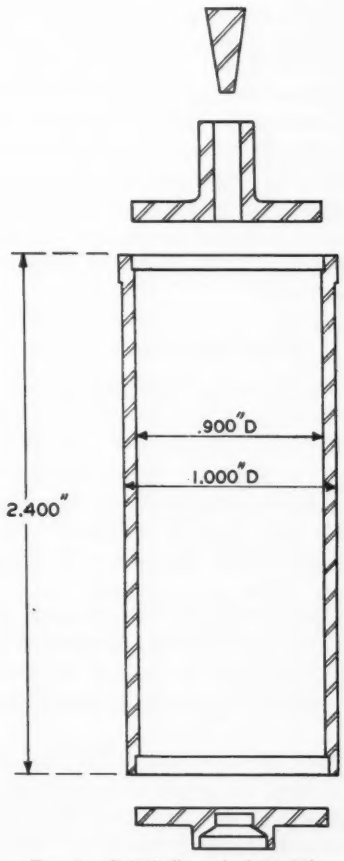

FIG. 1. C-22A Capsule (410 SS).

TABLE 1
Scope of Work

Fuels used	A gasoline stock; kerosene; stove oil; and JP-3, JP-4, JP-5 jet fuels
Radiation dosages	5×10^8 r, 10×10^8 r, 50×10^8 r; 0.5×10^{18}, 1.0×10^{18}, 2.5×10^{18} neutrons*/cm.^{2}
Test criteria	Physical property measurements related to combustion and handling

* Slow neutron component of combined reactor flux.

Presented at the joint American Society for Testing Materials - Atomic Industrial Forum Symposium on "Effects of Radiation on Materials," Annual Meeting, ASTM, Atlantic City, N.J., June 16–21, 1957.

This research was sponsored by the U.S. Atomic Energy Commission on Contract AT(11-1)-174.

Mr. Carroll is a Research Engineer and Mr. Bolt a Senior Research Chemist, both in the Petroleum Products Division; Mr. Bert is a Group Supervisor in the Engine Fuels Division.

TABLE 2
Effect of Gamma Radiation on Density and Hydrogen Content

Fuel	Gamma Dosage, 10^8 r	Density[20/4] gm./milliliter	Hydrogen, % by Weight
Stove oil	0	0.8543	12.9
	4.8	0.8613	12.9
	10.4	0.8644	12.5
	43.8	0.9006	12.9
JP-4	0	0.7936	13.8
	5.4	0.8083	13.4
	11.4	0.8162	14.0
	51.2	0.8700	12.8
JP-3	0	0.7765	13.9
	5.4	0.7656	14.2
	11.4	0.7826	14.3
	51.2	0.8603	13.2
Gasoline stock	0	0.7502	14.6
	4.8	0.7372	14.1
	10.4	0.7468	14.3
	43.8	0.8429	13.2

ured before and after irradiation. Density and percentage of hydrogen were obtained by standard procedures,[7] though on a microscale. Aromatic content was obtained by a combination of the fluorescent indicator adsorption method (FIAM)[7, 8] and infrared analysis. Volatility was observed by means of distillation curves from data obtained by ASTM Method D 86* procedure but in scaled-down equipment. The smoke volatility index (SVI)† was also obtained. This is an arbitrary term for expressing carbon deposition tendencies of a fuel. The SVI is principally affected by the aromatic content and boiling range of the fuel. Representative data on these properties are given in the following sections.

Gamma Irradiated Fuels

The density of the fuels increased and the percentage of hydrogen decreased as a result of irradiation. The more volatile fuels showed the greatest increase in density. This is shown by the results from four of the six fuels as summarized in Table 2. The density of the most volatile fuel, gasoline, increased 12.3 per cent, while the least volatile fuel, stove oil, increased only 5.4 per cent. Data on percentage of hydrogen are also summarized in Table 2. The decrease in hydrogen content reflected evolution of hydrogen on irradiation. However, the microtest for per cent hydrogen was not sufficiently accurate to determine if fuel type had any effect.

Distillations done according to ASTM Method D 86 procedure showed an increase in high boiling point material, indicating that high molecular weight polymers were formed during irradiation. The proportion increased for higher dosages. Fig. 2 gives this phenomenon very clearly for a JP-5 type of fuel. Similar data for a JP-4 type are presented in Fig. 3.

In addition to the increase in high boiling components, hydrocarbons were formed in some cases which had a lower boiling point than the starting material. This is shown in Fig. 4 for a gasoline stock. Table 3 summarizes distillation data for four fuels at the high dosage level. With the exception of the stove oil and the gasoline stock at the start, the boiling point of all fractions increased by a considerable factor.

Aromatic content was determined by FIAM on original stocks to establish a base line. This method is unsatisfactory for use with fluids whose boiling points exceed 500°F. Therefore, infrared spectrometry was used on original and on irradiated fuels to detect the desired differences. The results shown in Fig. 5 indicate changes of less than 1 per cent in aromatic content.

Decreases in the SVI indicate an increase in the carbon-forming tendency of the fuels on irradiation. Fig. 6 shows data on this point. The decrease in the SVI is caused primarily by the increase in high boiling components since the aromatic content remained essentially unchanged. The SVI is applicable primarily to fuels having a portion of the components boiling below 400°F., such as the JP-3 and JP-4 type of fuel. Specifications† prescribed an index value of 54 minimum for these materials.

The use of steel capsules permitted the measurement of gas pressure generated as a result of irradiation. For all fuels this was appreciable; as high as 20 volumes of gas per volume of fuel was evolved at the lowest dosage of 5×10^8 r. The amount of gas evolved was approximately linear with gamma dosage as shown in Fig. 7.

All fuels increased in viscosity upon irradiation. This was not significant at the lowest dosage but became so above 10^9 r. Typical values are shown in Fig. 8. These bracket the range of viscosity increase shown by the six fluids.

Olefin content was predicted by bromine number,‡ which is a satisfactory procedure for conventional fuels. Irradiated fluids, however, contain a wide variety of radiolytic products which also absorb bromine, and hence the correlation between olefin content and bromine number is not wholly valid. A larger fuel sample than available in this program would be required to obtain precise olefin contents by other test procedures. Therefore, olefin contents, as shown in Table 4, are approximate and are more qualitative than quantitative. The results do show, however, that olefins tend to increase appreciably as a result of irradiation.

Pile Irradiations

The JP-4, JP-5, gasoline stock, and kerosene fuels used in the previous gamma series were exposed to the combined flux of the Materials Testing Reactor. The reactor dosages used were 0.5, 1, and 2.5×10^{18} slow neutrons/cm.^{2}. The exposure vessels were introduced and removed from the pile by a hydraulic shuttle arrangement designated VH-3.

* *Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products*, 1956 Supplement to *Book of ASTM Standards*, Part 5, p. 8.

† "Fuel, Aircraft Turbine and Jet Engine, Grades JP-3, JP-4, JP-5," Military Specification MIL-F-5624C, May 18, 1955.

‡ Federal Test Method Standard, Method 3703, December 15, 1955.

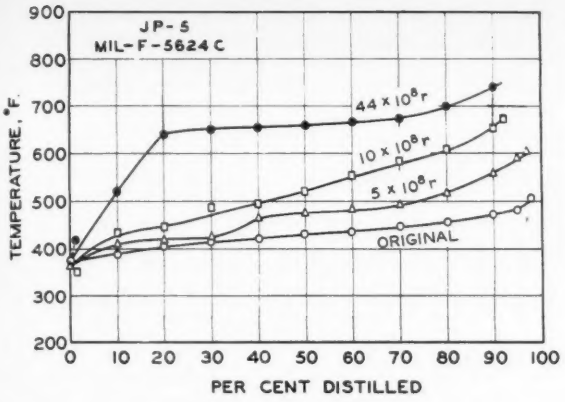

FIG. 2. Distillation of irradiated JP-5 jet fuel (micro ASTM D-86 method).

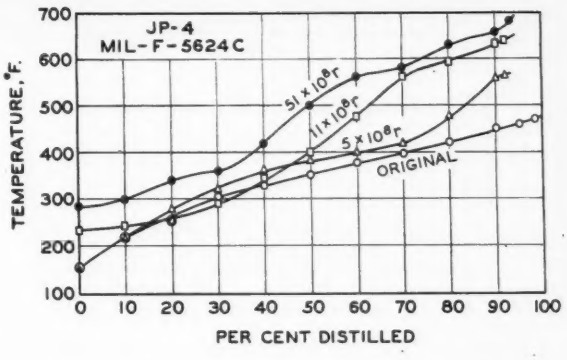

FIG. 3. Distillation of irradiated JP-4 jet fuel (micro ASTM D-86 method).

Results from this series of twelve samples showed the same trends observed for the gamma irradiated samples. The aromatic content remained constant, olefin content tended to increase, viscosity increased, and the gas evolved on irradiation was approximately linear with dosage.

Relationship of Pile Dosage to Gamma Dosage

The relationship between the damaging ability of gamma rays and neutrons can be approximated for the two radiation sources used by comparing effects on viscosity. Figs. 8 and 9 show, for four fuels, the change in viscosity at 100°F. from gamma and pile irradiation, respectively. From these curves equivalent gamma and pile dosage can be determined for a given fuel viscosity change. The result of cross-plotting these data in this manner is shown in Fig. 10. A dosage of 10^{18} slow neutrons/cm.^{2} corresponds to a gamma dosage of about 13×10^8 r. The reader is reminded that this approximation is based on a single physical property and applies only to the reactor facility used.

TABLE 3
Distillation of Irradiated Fuels

Designation	Temperature Change (°F.) for Given Percentage of Evaporation, 50 × 10^8 r Dosage				
	Start	10%	50%	90%	End Point
Gasoline stock	−44	−47	+152	+308	+423
JP-5	+6	+132	+229	+268	+228
JP-4	+164	+80	+148	+148	+199
Stove oil	−32	−6	+62	+164	+169

TABLE 4
Effect of Gamma Radiation on Olefin Content

Fuel	Gamma Dosage, 10^8 r	Bromine No.	% Olefins (Approximate)
JP-4	0	3	3
	5.4	14	13
	11.4	16	16
	51.2	18	23
JP-3	0	2	1
	5.4	13	11
	11.4	15	13
	51.2	21	20
JP-5	0	4	4
	4.8	13	16
	10.4	15	20
	43.8	13	22
Gasoline	0	2	1
	4.8	12	8
	10.4	13	8
	43.8	14	16

Conclusions

Several types of hydrocarbon fuels were exposed to gamma and pile radiation, and selected tests were performed on the irradiated samples. The tests were performed for the most part on a microscale. For the test conditions and fuels investigated, the following conclusions can be made:

(1) The percentage of hydrogen by weight decreases and density increases on irradiation.

(2) Radiation drastically changes the physical properties of fuels above 10^8 r gamma dosage. Materials of both higher and lower molecular weight than the original are formed.

(3) Gas is evolved as a result of irradiation. The quantity may be as high as 20 volumes of gas per volume of fuel at 5×10^8 r and increases approximately linearly.

(4) Radiation causes viscosity increases, although this is not appreciable below about 5×10^8 r.

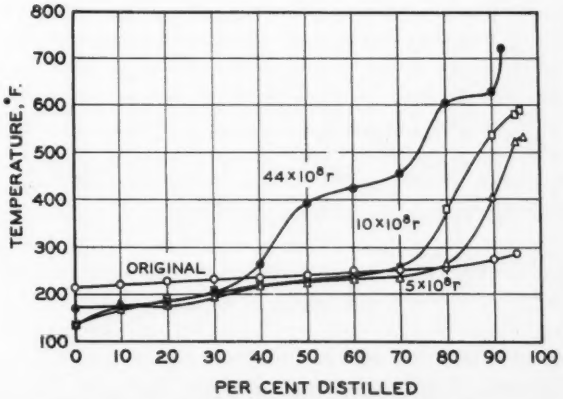

FIG. 4. Data on distillation of irradiated gasoline stock.

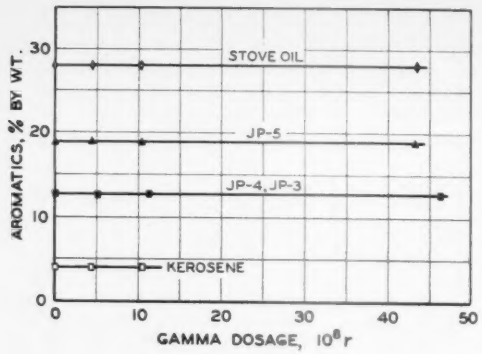

FIG. 5. Change in aromatic content with irradiation.

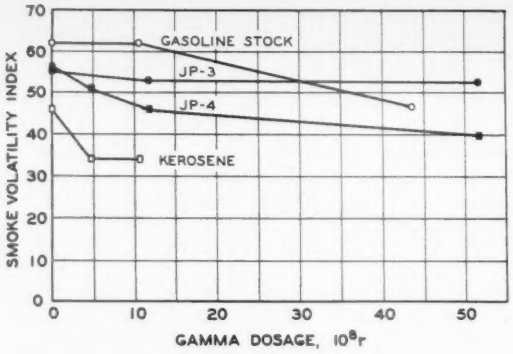

FIG. 6. Change in smoke volatility index with irradiation.

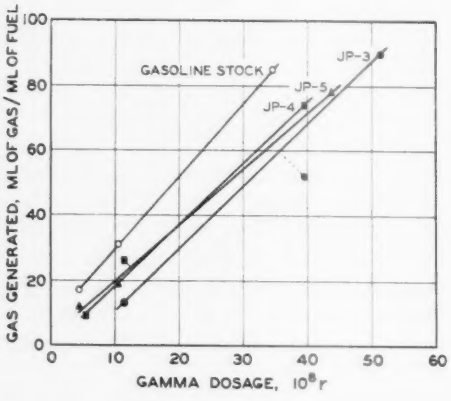

FIG. 7. Gassing of fuels during gamma irradiation.

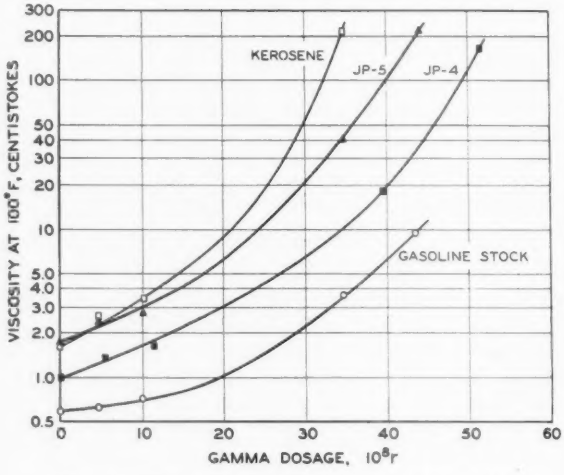

FIG. 8. Viscosity change of gamma irradiated fuels.

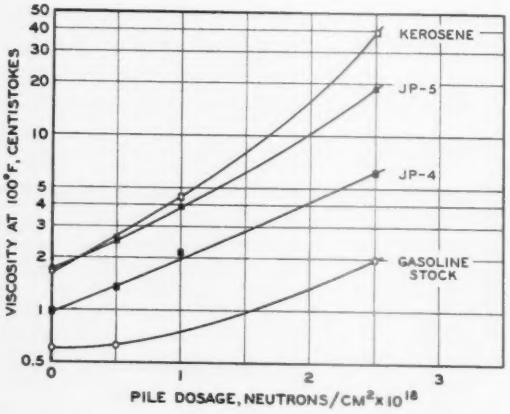

FIG. 9. Viscosity change of pile irradiated fuels.

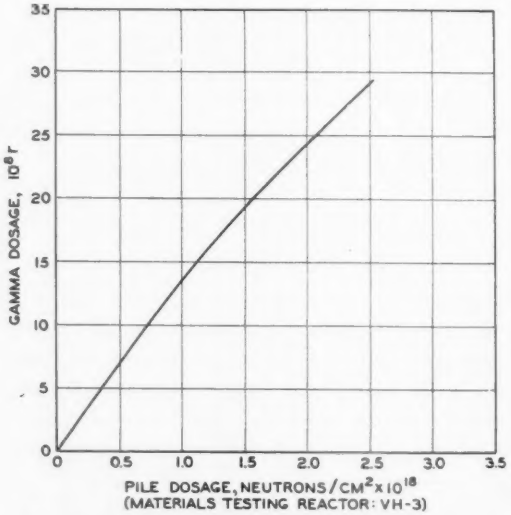

FIG. 10. Relation of pile dosage to gamma dosage for comparable viscosity change of hydrocarbon fuel.

(5) Olefins appear to increase appreciably on irradiation, although present methods do not permit a quantitative assessment of this change.

DISCUSSION

Curtis E. Lundblad*†

There are two points where our data are in conflict with those of the authors—namely, the effect of irradiation on the olefin and aromatic contents of fuels. The authors show that aromatic content remains substantially unchanged and olefin content increases with exposure to radiation. Based on our data, given in the accompanying Table 5, aromatic content increases and olefin content decreases with exposure to radiation. Our irradiations were also conducted in the MTR Gamma Canal, but standard rather than small-scale tests were used in determining olefin and aromatic contents both before and after irradiation. Such a difference in testing techniques might explain the discrepancies noted, although they probably arose from use of different sources of JP-4 and JP-5.

Except for the above discrepancies, our data confirm the authors' findings, although our work has not generally been at the high dosages investigated by them.

Other Discussion‡

Following the presentation, certain questions were posed: D. O. Leeser** inquired regarding the use of effective inhibitors with organic materials. E. Barry*** asked about the irradiation of fuels or other hydrocarbons in air. A. P. Allison†† was interested in what happens to the sulphur in fuels on irradiation. The paper was presented by Dr. W. T. Stewart,‡‡ the authors not being able to attend the meeting. As the questions posed were outside the scope of the paper, they are answered in greater detail in the following closure.

Authors' Closure

Aromatic and Olefin Contents

The accuracy of aromatic content determinations varies with the analytical method. The fluorescent indicator adsorption method (FIAM), in our experience, is unreliable for stocks having high boiling point constituents such as are formed during irradiation. In previous research, the FIAM indicated large effects of radiation on aromatic content: jet fuels, which were irradiated to a dosage of 2×10^{18} neutrons/cm.^{2} in the Oak Ridge graphite reactor, were found to increase fourfold in aromatic content; in another experiment a gamma irradiation of 10^9 r converted a kerosene to 100 per cent aromatic.

Table 5
Effect of Radiation on Aromatic and Olefin Contents

Radiation Dose, r	Aromatics, %		Olefins, %	
	JP-4	JP-5	JP-4	JP-5
0	16.7	13.0	2.9	2.3
3×10^7	17.6	13.7	2.1	1.7
10^8	16.7	15.4	2.7	3.5
3×10^8	40.6	37.9	0	0

The scheme of using the FIAM in conjunction with infrared spectrophotometry appears to be more satisfactory. The absolute level of aromatic content is determined by the FIAM on original stocks for which it is reliable. The degree of change is then determined by comparing the absorption at significant wavelengths in the infrared or ultraviolet regions for the original and irradiated materials. By this combination of techniques, we found that the change in aromatic content for the kerosene was less than 1 per cent after exposure to 10^9 r.

Accurate techniques for determining olefin content on a microscale were not available. Standard infrared photometric methods were inadequate as some species of olefins—e.g., tetra substituted olefins—do not absorb in the infrared. As noted in the paper, bromine absorption is not considered to be an accurate means of determining olefin contents of irradiated fuels. The data of Table 4 are at best an approximation.

Inhibitors

The effect of additives on various organic fluids in the lubricating oil range has been extensively studied.[9] Generally speaking, selected inhibitors are effective in retarding radiation damage. Usually, they are less effective in the more radiation-resistant base fluids.

The best additives were the alkyl selenides.[10] These materials retarded radiation damage, as measured by viscosity increase, either in the absence of air or in its presence. Organo iodine compounds, such as iodobenzene, which are not normally considered as oxidation inhibitors, were also effective in reducing radiation damage. Compounds containing sulphur in general were also effective.

Inhibitors may increase the useful life of hydrocarbon lubricants fourfold. The effects of inhibitors on hydrocarbon jet fuels have not been studied, and they cannot reasonably be extrapolated from the work with lubricants. Critical properties and criteria of damage are different for both products.

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† Presented in written form.

‡ Given orally.

** Head, Materials Section, Atomic Power Development Associates, Detroit, Mich.

*** Senior Technologist, Research Lab., Socony Mobil Oil Co., Paulsboro, N.J.

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‡‡ Division Supervisor, Petroleum Products Research Div., California Research Corporation, Richmond, Calif.

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Irradiation Atmosphere

No study of the effects of exposure atmosphere was conducted with the hydrocarbon fuels. However, such a study was made with various other types of organic fluids including polyphenyls.[11] It was shown from exposures in nuclear reactors that damage measured by viscosity increase was accelerated more than twofold by the presence of air.[11] Oxidation tests were also conducted inside a nuclear pile. Changes in viscosity and acidity observed in identical tests in the absence of radiation were minor compared to the changes which occurred inside the pile.[9] These experiments were conducted at 285°F.

Sulphur Content

No data are available on the fate of the sulphur in hydrocarbon fuels during irradiation; we know of no work in progress along these lines.

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[10] Denison, G. H., and Condit, P. C., *Oxidation of Lubricating Oils—Dialkyl Selenides as Inhibitors*, Ind. and Eng. Chem., Vol. 41, p. 944, May, 1949.

[11] Bolt, R. O., and Carroll, J. G., *Organics as Reactor Moderator-Coolants—Some Aspects of Their Thermal and Radiation Stabilities*, Proceedings of the International Conference on Peaceful Uses of Atomic Energy in Geneva, August 8–20, 1955, Vol. 7, p. 550 (United Nations, New York, 1956).

✦ ✦ ✦

Pneumatic System Design (Continued from page 55)

Conclusions

The following recommendations, based on our experiences, are offered for consideration for future pneumatic systems:

(1) Pneumatic systems should be placed in the same category as prime structure and thereby be afforded an equivalent top priority. An effort should be made to coordinate structure with the pneumatic system instead of the general practice of completing structural design first and then forcing ducting compromises.

(2) A tension-type system, because of its relative simplicity and lighter weight, is preferred over a compression design. However, a strong point is made of the fact that careful consideration of fail-safe criteria is essential and, further, that final system-type selection will be governed by available space for the duct system, operating maximums, and capabilities of attaching structure. Final system-type selection should be dependent on specific considerations directly associated with any new model. Every effort, however, toward the use of a tension-type system is encouraged.

(3) A specific set of pneumatic duct and bracket design criteria, conceived from theory but aligned by experience, should be established. The criteria should be thorough and basic enough so that a designer with minimum experience could step in and design in accordance with the established practice.

(4) Component proof tests, system tests, and other development tests are essential and should be conducted well in advance of the first installation. A full system mock-up is invaluable.

(5) Mutual understanding and agreement of all departments involved is essential at the outset of a design to ensure proper tooling and location of master tooling points.

(6) Reduction of bleed air temperatures and pressures as soon as possible to the maximums required for effective system operation would tend to ease the problem.

(7) A lightweight flexible duct connector to accept relative motion should be developed and put into use. A ball joint or a knuckle-type unit with a rotating end capable of bending and rotation is considered in order.

(8) All new manufacturing processes and techniques should be proved by production methods before adoption.

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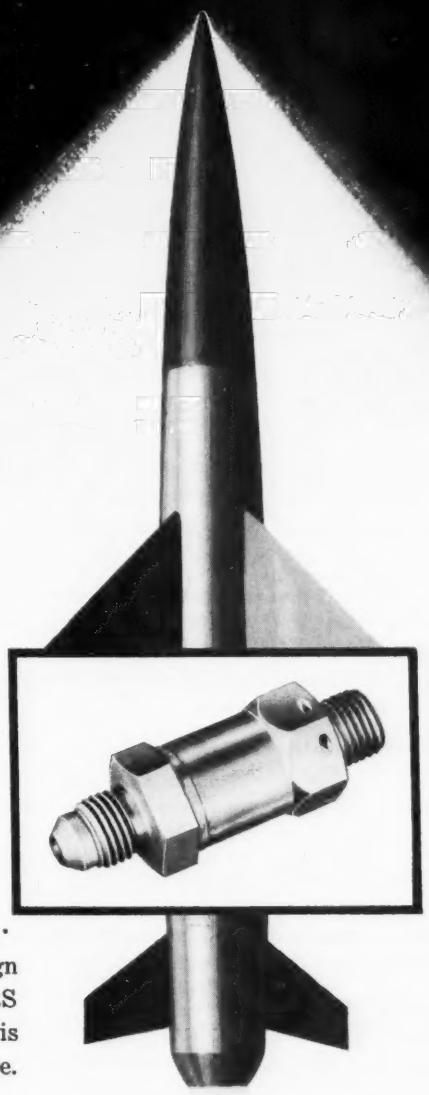

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CORPORATE MEMBER NEWS

•**Aerojet-General Corporation** has announced a joint partnership agreement with Stauffer Chemical Company to develop and produce boron fuel compounds. Aerojet also announced that it has acquired complete ownership of its subsidiary Aerojet-General Nucleonics.

•**Aerophysics Development Corporation (a Curtiss-Wright Subsidiary)** reports the appointment of Dr. Ernst Steinhoff as Associate Technical Director.

•**American Airlines, Inc.,** has appointed Bonham M. Fox of its Chicago sales staff as Director, Passenger Sales. Miss Mildred Jackson has been named Director of the newly created Women's Division, Customer Service Department.

•**American Steel & Wire Division, United States Steel Corporation,** has announced the promotions of Charles E. Cronauer, Jr., to Assistant to General Traffic Manager, and Norman S. Brubeck to Manager, Transportation.

•**Avien, Inc.,** has announced the appointment of John Thoerle as Eastern Regional Manager.

•**Bell Aircraft Corporation** reports that construction has begun on a $2.5 million addition to its main plant adjacent to Niagara Falls Airport. The twofold plan calls for an Electronic Data Processing Center first and, later, the Lawrence D. Bell Research Center.

•**Bendix Aviation Corporation** has announced establishment of a new controls section to engineer, manufacture, and sell tape-controlled production systems. . . . International Division reports the appointment of Frederick J. Borheck as Aviation Sales Manager. . . . Products Division, Missiles Section, has a new General Manager, Arthur C. Omberg, who replaces the late W. L. Webb. Other division promotions: Emil O. Wirth to General Factory Manager, and Richey W. Whitesell to Manager, Airframe Products. . . . James P. Buckley has been named Director, Sales and Service, Eclipse-Pioneer Division. . . . James E. Young has been appointed Manager, Dayton Sales Office.

•**Douglas Aircraft Company, Inc.** . . . El Segundo Division has named two IAS members as recipients of the division's annual engineering achievement awards: Charles J. Da Ros (A), Aerodynamics Design Specialist, and William D. Van Dyke, Electrical Engineer.

•**Fairchild Engine and Airplane Corporation** has named George F. Chapline, Vice-President and General Manager, Fairchild Engine Division, as Director of Military Requirements for the corporation.

•**The Garrett Corporation** has announced the election of E. A. Belande as Vice-Chairman of the Board. Other appointments: R. J. Wright to Manager, Washington, D.C., office; Myron A. Tracy to Manager, Military Contracts and Support Programs; and William G. Orr as Director, Support Services Programing. The AiResearch Aviation Service Division has enlarged its metal fabricating department facilities, the firm also announced.

•**General Dynamics Corporation,** Convair Division (Fort Worth), has established a new subsystems procurement department headed by Robert Kahn. . . . Convair San Diego reports installation of a numerical director unit as part of a cooperative program to provide magnetic tapes for numerically controlled machine tools in the industry throughout the west. The division also announced installation of a centrifuge to test ICBM components. . . . Gordon G. Hoit, Executive Vice-President, Stromberg-Carlson Division, has been elected to the Board of Trustees, Rochester Chamber of Commerce.

•**General Precision Equipment Corporation** . . . General Precision Laboratories, Incorporated, has announced the opening of a new 22,000 sq.ft. engineering building at Pleasantville, N.Y.

•**Kelsey-Hayes Company** . . . Utica Metals Division has announced completion of a new 110,000-sq.ft. plant for increased production of vacuum induction melted alloys. . . . Frank P. Coyer, Jr., has been elected Treasurer of the company.

•**Lear, Incorporated** . . . Sales and service activities of Lear S.A., Geneva, Switzerland, have been sold to a new Swiss firm, Electravia S.A., the firm announced. Henry M. Wales has been appointed to the newly created position of Commercial Products Marketing Manager for all divisions. . . . W. R. Barnes has been named Grand Rapids Division Components Marketing Manager.

•**Lockheed Aircraft Corporation** . . . Missile Systems Division reports that an administrative area and a multipurpose building have been completed at a 4,000-acre missile testing facility under construction south of San Francisco, Calif. . . . Georgia Division announced that Harvey C. Christen, Quality Control Director, has been transferred to the California Division. O. Ernest Erwin will fill the vacancy at Marietta. J. W. Farnell, formerly Missile Systems Division Industrial Relations Manager, has been named Labor Relations Manager at Marietta.

•**Minneapolis-Honeywell Regulator Company** has announced the appointment of Robert E. Forney as Assistant to the Director, Service Engineering, at the firm's inertial guidance plant, St. Petersburg, Fla.

•**Northrop Aircraft, Inc.** . . . Northrop Division reports that the first contingent of some 2,800 engineers and scientists has begun to occupy the firm's new research center.

•**Pan American World Airways, Inc.,** reports that construction has been completed on a 10,000-sq.ft. "staff house" at Frobisher Bay in northeastern Canada, a Polar route refueling stop.

•**Piasecki Aircraft Corporation** and Ateliers d'Aviation Louis Breguet of France have announced an agreement for direct interchange of technical and product information.

•**Ryan Aeronautical Company** has announced the appointment of Leon T. Noel as Executive Assistant to the firm's Secretary and Treasurer, C. A. Stillwagen. Mr. Noel formerly was Vice-President of Finance and a member of the Board, Solar Aircraft Company.

•**Shell Oil Company** has announced a new class of greases for high-temperature, high-speed applications in missiles and supersonic aircraft, called Shell ETR, which is said to withstand heat up to 600°F. and speeds up to 30,000 r.p.m.

•**Solar Aircraft Company** has added six scientists and engineers to its research and development engineering division: Karl F. Greil, F. W. Ross, Laurence H. Cherry, Morris Kaswen, M. C. Towns, Jr., and Daniel H. Driscoll, Jr.

•**United Aircraft Corporation** . . . Hamilton Standard Division has announced that Edward F. McDonough has joined the staff of the Electronics Department.

•**Vickers, Incorporated,** has named John W. Rowan Service Manager, Detroit Aero Hydraulics Service Section.

•**Westinghouse Electric Corporation** has announced the election of Mark W. Cresap, Jr., as President and Chief Administrative and Operating Officer; E. V. Huggins as Board of Directors Executive Committee Chairman and Vice-President; John K. Hodnette, Executive Vice-President; George G. Main, Vice-President—Finance; Francis E. Dalton, Controller; Carlisle P. Myers, Corporate Secretary; and Russell B. Read, Assistant Treasurer. . . . The Aviation Gas Turbine Division reports installation of an 8,000-hp. synchronous motor for testing jet-engine compressors. Richard S. Huested has been named division Manager of Operations.

•**Weston Instruments Division of Daystrom, Inc.** . . . Thomas Allinson has been appointed President and Chief Operating Executive of the division, Daystrom has announced.

Change of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

Notices should be printed legibly and sent directly to the Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

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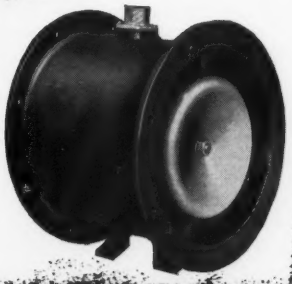

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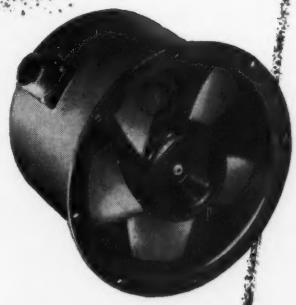

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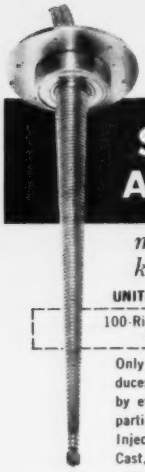

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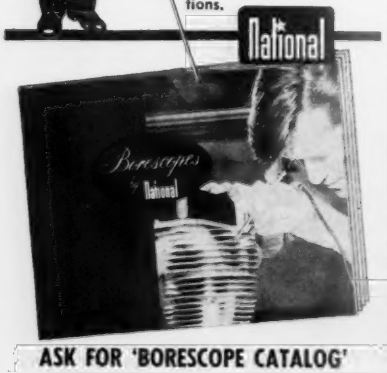

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IAS SECTIONS

Dayton Section

Bell VTOL Research; Satellites Summarized

James O'Malley, Jr., Chief, Aerodynamic and Propulsion Design, Aircraft Division, Bell Aircraft Corporation, reviewed Bell's work on VTOL aircraft during the last 5 years, at the December meeting.

He pointed out that his firm's work has been devoted to rotating thrust line jet VTOL's rather than tail-sitter types. He said most flight-test vehicles developed in the field have solved VTOL technical problems.

On November 21 the Section was joined by its ARS Cincinnati counterpart to hear "Fundamentals of Satellites" discussed by Rudolph Hermann, Professor of Aeronautical Engineering, University of Minnesota.

Instead of emphasizing the glamorous aspects of satellites, Dr. Hermann covered the basic laws of ellipsis and gravitation, then derived the velocity equations for a satellite in an orbit 300 miles above the earth. He also gave his personal estimate of the size and thrust of the Soviet rockets used to launch Sputniks I and II.

JOHN S. MCCOLLOM, *Secretary*

Detroit Section

GI Needs Economical One-Man Aircraft

More than 60 members and guests heard Brig. Gen. William B. Bunker discuss "Individual Air Mobility and the Soldier" at the November 12 meeting. General Bunker is Commander, U.S. Army Transportation Supply and Maintenance Command.

He listed the possibilities and problems of one-man vehicles in a combat unit. Emphasizing that he was giving his own opinions, he described a complete series of one-man vehicles to illustrate the state of the art.

He said that if a one-man vehicle is required, there are a number of technically feasible solutions, but in general, all the small units are thirsty fuel consumers. There seems to be no unit capable of lifting an infantryman with 50 or 60 lbs. of equipment.

RICHARD CHUTE, *Secretary*

Hampton Roads Section

Boron Uses Described; Report on Farnborough

Claude P. Talley of Experiment, Inc., discussed "Boron Combustion and Uses" at the November meeting.

Boron has the desirable qualities of high heat combustion per unit weight and per unit volume, he said. Two possible methods for burning boron are transporting oxygen to solid surface and transporting oxide products away, and transforming solid boron to gas phase to react with oxidizer.

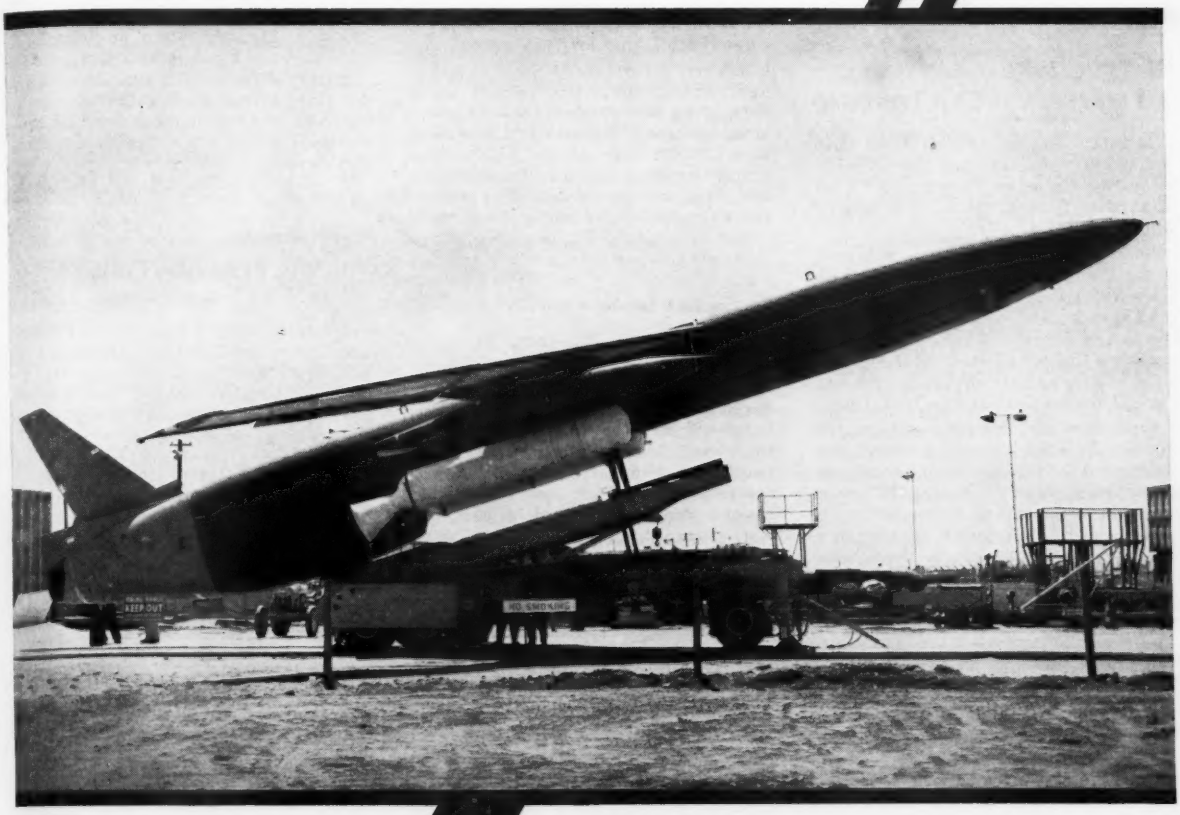
Increasing the temperature of boron also increases the rate of burning by increasing the rate of evaporation of the oxide products. Boron has been found to be a semiconductor, the electrical resistance of which drops with increase in temperature.

▶ The October meeting featured a "Report on Farnborough" by H. Reese Ivey, Deputy Director, Operational Analysis, Tactical Air Command, and Col. Jack L. Crawford, Jr., Deputy Director, Requirements, TAC.

Colonel Crawford described the organ-

Hampton Roads Section Chairman Lewis Fisher welcomed two guest speakers, a guest, and a new Section member at the October meeting. They are *left to right*: Speaker H. Reese Ivey, Tactical Air Command; Mr. Fisher; guest Wing Comdr. I. S. Smith, RAF; speaker Col. Jack L. Crawford, Jr., TAC; and new Section member Vice-Adm. James S. Russell, Deputy Commander in Chief, Atlantic Fleet. This issue carries a report on the meeting.

Checks heat on the Snark!



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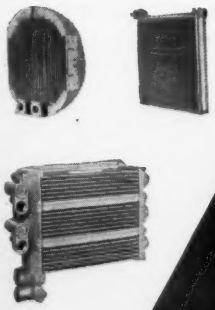

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ization of British armed forces from the point of view of major types of current aircraft each service uses.

Mr. Ivey showed movies he took of the many aircraft and missiles on static display and in flight, giving a running commentary on the types.

PAUL A. HUNTER, *Secretary*

Indianapolis Section

115 Members Visit CAA Tech Center

Members and guests visited the Civil Aeronautics Administration Technical Development Center on December 9. CAA hosts were Alan L. Morse and Charles Middlesworth.

Short comprehensive papers presented at the Center were "Visual Mid-Air Collision Avoidance" by R. B. Fisher; "Cockpit Vision Studies" by E. E. Pazera; "Inspection of Adhesive Bonding of Helicopter Rotor Blades" by R. C. Mulvey; and "The Development of Crash-Resistant Fuel Tanks for Aircraft" by J. H. Clark.

Equipment and operations seen at the Center's facilities included fire resistance testing and fire protection equipment, fire protection tests on the Boeing 707 power plant, development of improved traffic control, and development of birdproof windshields. Comments on these were provided by CAA specialists.

A. R. STOKKE, *Program Committee*

Los Angeles Section

Panel Discussion on Farnborough

Five speakers contributed a panel discussion on the 1957 SBAC Farnborough Show at the November 21 meeting. These were Lt. Gen. L. C. Craigie, USAF (Ret.); George H. Hoffman, The RAND Corporation; Capt. Iven C. Kincheloe, Jr., USAF; Welko Gasich, Northrop Aircraft, Inc.; and Fred Felberg, Southern California Cooperative Wind Tunnel.

The panel described various segments of the show. Movies were shown.

▶ Members at the November 15 historical meeting heard a review of icing presented by Lewis A. Rodert, Project Engineer, R&D Lockheed. He described the first encounter with icing problems, covered early research, and traced the development on anti-icing systems of American, British, German, and Russian designs.

Engine installation specialists heard Alan C. Brown discuss "Transient Performance Predictions" at the November 12 meeting. Mr. Brown is a Research Associate at the University of California Engineering Center.

He emphasized the importance of understanding transient characteristics in engine-inlet systems in the prediction of modes of oscillation and their corresponding damping. He also discussed pressure noise level, wake effects, and engine noise. In conclusion he described recent results of diffuser impedance measurements and discussed the relation of inlet buzz to the linear system approach.

DANA MORAN, *Secretary*

Rocky Mountain Section

Ejection Development

More than 100 members and guests heard Richard H. Frost, Vice-President, Stanley Aviation Corporation, discuss "Escape From High-Speed Aircraft" at the December 3 meeting.

Mr. Frost outlined the history of escape from aircraft, covering the development of upward and downward ejection seats. He said his firm is currently working on an escape capsule for the XF-102 that will have aerodynamic stability, an oxygen supply for descent, and flotation capability and will provide exposure protection for the pilot after landing.

DONALD A. KNOWLTON, *Secretary*

San Francisco Section

Officers for 1958

New Section officers introduced at the December 19 meeting were Chairman, Robert McIver, United Air Lines; Vice-Chairman, Robert Crane, NACA Ames Laboratory; Secretary, Daniel Bershader, Stanford University; and Treasurer, Norman Bergrun, Lockheed Missiles.

C. W. Harper reviewed the proceedings of the Sixth Anglo-American Conference and related his personal impressions of recent aeronautical research and development in Europe.

ROBERT M. CRANE, *Secretary*

Tulsa Section

Visit to Douglas Division

The Tulsa Division, Douglas Aircraft Company, was host to 35 members and guests who visited its Antenna and Radome Development Laboratory on December 10. H. E. Felix and G. A. O'Reilly of Douglas were tour directors.

Visitors saw a demonstration of antenna radiation patterns of a stub antenna on the three axes of an RB-66 scale model. Methods of determining radome efficiencies and coaxial cable and antenna efficiencies also were presented.

B. D. OLSON, *Recording Secretary*

Wichita Section

SAC Capabilities Outlined by General Knapp

Members were joined by their ARS and SAE counterparts on December 4 to hear Brig. Gen. James B. Knapp, USAF, discuss "Airpower Today and Tomorrow." General Knapp is Director, Installations Engineering, SAC.

He reviewed the history of SAC, its current status and capability. General Knapp also explained SAC communications and training.

He said SAC has three forces in the United States—at Shreveport, La., March AFB, Calif., and Westover AFB, Mass. Its communications center is at Offutt AFB, Neb.

LYMAN L. PETERSEN, *Pro Tem Secretary*

STUDENT BRANCHES

Indiana Technical College

At the first meeting of the winter term on December 10 a field trip to the NACA Laboratory at Cleveland was planned.

Twelve candidates received their membership cards after completing the requirements for full membership.

After the business meeting, a movie entitled *Flying Colors* (United Air Lines) was shown.

HERBERT D. KREDIET, *Secretary*

Institute of Technology, USAF

On November 27, 130 members and guests heard Dr. Von Ohain and Robert Hunter of the Aeronautical Research Laboratory, Wright-Patterson AFB, Ohio. The address was a brief coverage of propulsive energy types. Propulsion from chemical, environmental, and annihilation energy was discussed.

Also covered was a comparison of various missions into space, including trips to the moon and return or to Mars and return.

CAPT. DAVID W. HALL, USAF, *Secretary*

Mississippi State College

Robert E. Perkinson, Chief, Data Analysis, MacDonald Aircraft, spoke on "General Data Analysis" in November.

Mr. Perkinson began by giving a general outline of the step-by-step process of aircraft conception, development, and production and showed how his department worked with the entire process of aircraft synthesis. He also showed actual flight-test films of the F-101.

Albert George Bennett, Jr., and Cecil Franklin Thweatt were recipients of Delta Airline scholarships, worth $300.

RICHARD W. HICKS, *Secretary*

New York University

Two films shown at the November 25 meeting were *Here Comes the Hercules* (Lockheed) and *Flight Report on the X-1A* (Bell). Films shown after a business meeting on November 18 were *Hydrostatic Testing of the C-130A* and *First Flight of the B-58*.

At the November 11 meeting Faculty Adviser Professor Strom announced that

permission had been granted by the Aeronautical Engineering Department to use its wind tunnel.

The Branch plans to construct a 48-in. delta wing and to study differential flap characteristics. A smoke tunnel project also will be undertaken in which forces on the model will be measured by a straingage device and by photography.

ISAAC FERNANDEZ, *Secretary*

Princeton University

Jack E. Stephenson, Engineering Test Pilot, Grumman Aircraft, was guest speaker at the December meeting. He spoke on "Flight Test and Its Cooperation With Engineering."

Mr. Stephenson discussed the principal objectives, methods, and problems of flight testing, as well as pilots' views. He emphasized that it is the practical point of view, not the academic point of view, that is needed in flight testing.

He stated that, in general, flight test covers two periods of time: (1) when the airplane is initially conceived to its delivery to the flight-test group and (2) the introduction of the aircraft to its user to the end of its operational life.

He covered the actual testing of a plane in flight, outlining three primary phases: the test pilot determines whether the plane will fly and whether it does so safely, and he looks for any unusual characteristics which might be present; during the second phase the plane is pushed to its limits; while the third phase concerns the testing of external stores.

JAMES S. MCDONNELL, III
Secretary-Treasurer

Rensselaer Polytechnic Institute

"The Gyroscope and Its Applications" was discussed on November 13 by Burt L. Newkirk, Professor Emeritus of the Institute, before 60 members and guests.

Dr. Newkirk explained the reasons for gyroscopic resistance with simple vector diagrams. Then he demonstrated the resistance and precession using a large gyroscope. The application of the gyroscope to the monorail car was illustrated by attaching the gyroscope to a small but heavy platform and pushing it out over the audience on a single wire.

CHARLES KROMER, *Secretary-Treasurer*

Tri-State College

Sixty-two members and guests present at the semiannual banquet on December 5 heard an address by M. G. Beard, Assistant Vice-President, American Airlines, on "The Problems Encountered in Deciding Upon a Jet Transport." Mr. Beard spoke of the problems involved in designing jet transports that would provide both economy and speed.

Professor Charles Libove, Faculty Adviser, announced that the winner of the Scholastic Award for seniors was Donald Schard.

ROBERT A. SPALDING, *Secretary*

University of Detroit

Robert Snow, Regional Sales Manager, Continental Aviation, spoke on "The Future of the Small Gas Turbine in Aviation" at the December 18 meeting.

He reviewed the pros and cons of four gas-turbine engine types, concluding with the opinion that the free shaft turbine will become more prominent. He said its advantages include multifuel capacity, no warmup time, reduced vibration, low maintenance, small gross weight, and good short field capabilities.

Later, two films *Jet Test* (USAF) and *Flight Into Future* (Bell) were shown.

▶ More than 50 members and guests heard a discussion on the Branch's half-hour television show at the first meeting of the winter quarter.

The first show called "Rocket Engines" was produced at the campus TV and radio studio, then televised over Detroit's educational station WTVS. This consisted of a factual discussion of rocket engines by Branch members and a few demonstrations. The Branch TV Committee also scheduled a show on "The Sound Barrier."

Plans were formulated for the presentation of oral reports of NACA Technical Reports by volunteer members.

A film *Air Force Medicine* was shown, and booklets titled *Pocket Data for Rocket*

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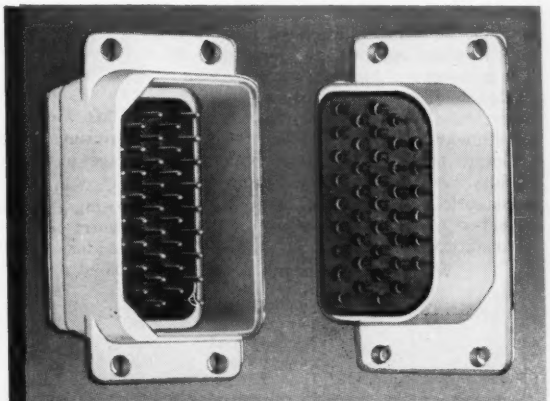

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Major David G. Simons, USAF, spoke on his balloon research flight of 102,000 ft. on December 3 before the Polytechnic Institute of Brooklyn IAS Student Branch and its ARS counterpart.

Engineers (Bell Aircraft) were distributed.

STEVE SOPCZAK, *Reporter*

University of Notre Dame

Howard Williams discussed "The Philosophy of Control Designs in Gas Theory Engines" at the November 20 meeting. Mr. Williams is Group Supervisor, Product Design Group, Bendix Aviation Corporation.

He illustrated his talk with slides showing the makeup and function of basic fuel control systems. Later, a short film on the 1956 Thompson Trophy races was shown.

▶ Some 45 members attended a banquet and business meeting on November 6. The meeting was highlighted by a film on guided missiles from Bendix and an after-dinner talk by Patrick Poynton, a graduate student.

Guests included Vincent Goddard, Faculty Adviser and Assistant Professor of Aeronautical Engineering, and Robert Eikenberry, also Assistant Professor of Aeronautical Engineering.

WILLIAM B. MAGUIRE, *Secretary*

University of Oklahoma

Some 100 student members and guests heard a talk by Howard F. Marx, Chief, Operational Research, Temco Aircraft, at the meeting on December 5.

Mr. Marx discussed the importance of operations research and its application of scientific data. He explained how operations research is used to replace guesswork with scientific appraisal of the problem.

WANDA J. LITTLE, *Secretary*

University of Wichita

A talk by Richard Holloway, Aerodynamics Department at Boeing Airplane Company, on "Project Vanguard" was featured at the November meeting.

Mr. Holloway divided his talk into descriptions of the first, second, and third stages of the rocket, and the satellite.

▶ A field trip was held on October 11 at Boeing Airplane Company, with Larry Robertson, C. Commisky, and Douglas Hadden as guides. The main departments visited were the Supersonic Wind Tunnel, Process Labs, Structural Testing Section, and the Digital Computing Section.

RICHARD E. MONICAL
Secretary-Treasurer

University of West Virginia

Professor Bohdan Hnatiuk gave an address on "Space Satellites" on December 5. Escape velocity was shown to be determined by kinetic and potential energy equations. The importance that the velocity and its direction at the perigee has on determining the orbit of the satellite also was mentioned.

JACK H. HUNTER, *Secretary*

University of Wyoming

On December 3 the Branch saw a movie entitled *Progress Report on the F-104*. This is a Lockheed film showing the history of the F-104 from the completion of the preliminary design to its first test flight.

ROBERT J. MILLER, *Secretary*

Virginia Polytechnic Institute

The Branch heard an address by Anshal I. Neihouse, head of the NACA Spin Tunnel System, on November 19.

Mr. Neihouse's talk centered around the problem of spin in aircraft. He briefly explained some of the research that has been conducted in the spin tunnel at Langley. Through the use of accurate scale models, he and his staff are able to predict the spin characteristics of an aircraft before the prototype is built.

The models used are equipped with small magnets that are mechanically linked to control surfaces. Large bus-bars encircle the tunnel. When they are energized, the magnet in the model aligns itself with the lines of flux through the tunnel thus changing the control surfaces to any predetermined position. This method of control is used to study spin recovery without touching the model which floats in free flight in the tunnel.

JAMES T. MCDANIEL, *Secretary*

NATIONAL NAVAL AVIATION MEETING PROCEEDINGS

The *Proceedings* of the Naval meeting (held in San Diego, Calif., August 5–10, 1957) contains all *unclassified* papers presented at the meeting and is now available.

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Acoustics, Sound, & Noise

Noise Research in the United Kingdom. E. J. Richards. *(CAI Annual Gen. Meeting, Ottawa, May 27, 28, 1957, Preprint 717.) Can. Aero. J.*, Dec., 1957, pp. 341–357. 48 refs.

Silencer for Ground Run-Up of Jet Engines. Eve Sassarsson. *Saab Sonics*, No. 25, 1957, pp. 9, 10, 26. Description of an air-cooled exhaust-gas silencer with movable intake silencers, designed for use in the Saab 32 Lansen.

Survey of Methods for Evaluating and Measuring the Diffuseness of a Sound Field. V. V. Furduev. *Sov. Phys. - Acous.*, July - Dec., 1955, pp. 312–326. 21 refs.

On the Problem of Mutual Interaction Between Soundwaves. A. G. Gorelik and V. A. Zverev. *Sov. Phys. - Acous.*, July-Dec., 1955, pp. 353–357. Development of a method for detecting and investigating the interaction between acoustic waves in liquids.

Concerning Certain Second-Order Quantities in Acoustics. N. N. Andreev. *Sov. Phys.-Acous.*, Jan.-June, 1955, pp. 2–11. Investigation of the density and flux of sound energy and of the momentum and pressure of the sound radiation.

Concerning one Type of Attenuation of Waves Propagating in Inhomogeneously-Stratified Media. L. M. Brekhovskikh and I. D. Ivanov. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 23–31. Analysis of the propagation of waves in a layer, bounded on one end by an inhomogeneous medium, in which the velocity of the wave propagation diminishes with the increasing distance from the layer boundary.

Concerning the General Relationship Between Absorption and Dispersion of Sound Waves. V. L. Ginzberg. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 32–41. Derivation of previously known results on the propagation of electromagnetic waves. Analogous equations are then obtained to relate the velocity and absorption coefficient of sound.

Field of a Spatially Extended Moving Sound Source. Hans L. Oestreicher. *ASA J.*, Nov., 1957, pp. 1,223–1,232. 27 refs. Rigorous determination of the field for a sound source moving with subsonic speed in a viscous compressible gas, formulated as an initial-boundary value problem of a system of linear partial differential equations.

Diffraction of Plane Sound Waves by a Spherical Cavity. D. V. Sivukhin. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 82–93.

Experimental Investigation of Diffraction of Acoustic Waves by Periodic Structures. A. N. Leporskii. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 50–59. Presentation of experimental patterns for scattering by sinusoidal and sawtooth surfaces, and comparison to theoretical values calculated by means of the Brekhovskikh method.

Scattering of Sound from Plane Inhomogeneous Surfaces with Periodically Varying Acoustic Admittance. Iu. P. Lysanov. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 60–72. Development of a method for calculating the scattering of sound from a plane inhomogeneous surface characterized by a normal impedance or acoustic admittance which is independent of the angle of incidence of the sound wave.

Representation of the Field of an Acoustic Source as a Series of Multipole Fields. Hans L. Oestreicher. *ASA J.*, Nov., 1957, pp. 1,219–1,222. Development of a method applicable to sources which are small compared to the wavelength.

Correlation of Amplitude and Phase Fluctuations for Wave Propagation in a Medium with Random Irregularities. I. A. Chernov. *Sov. Phys.-Acous.*, Jan.-June, 1955, pp. 94–101. Calculation of the coefficient of correlation for amplitude and phase fluctuations at the reception point.

Survey of Methods for the Visualization of Ultrasonic Fields. I. D. Rozenberg. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 105–116. 45 refs. Study of the basic parameters, quadratic effects, and secondary effects in visualizing the sound fields—in particular, the visualization of sound images.

Measurement of the Acoustic Parameters of Materials at Ultrasonic Frequencies by Means of a Pulse Pipe. N. S. Ageeva. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 117–127. Development of a method for measuring the complex reflection coefficient from a plane surface at ultrasonic frequencies by means of a hydroacoustic device called a "pulse pipe."

The Radiation of Sound by the Vibrating Boundaries of an Arbitrary Wedge. I. G. D. Maliuzhinets. *Sov. Phys. - Acous.*, Jan.-June, 1955, pp. 152–174. Application of the Sommerfeld integral to obtain an accurate solution for the sound pressure field which is caused by the vibration of the boundaries of a wedge-shaped region.

Scattering of Acoustic Waves at Small Inhomogeneities in a Waveduct. M. A. Isakovich. *Sov. Phys. - Acous.*, Jan.-Mar., 1957, pp. 35–45. Application of the method of small perturbations to find the field of singly-scattered waves in a plane waveduct with small inhomogeneities.

Noise Characteristics of the Caravelle. *Shell Av. News*, Sept., 1957, pp. 15–18. Comparison of the take-off noise characteristics of Sud-Aviation Caravelle with those of conventional propeller-driven airliners.

Comparison of the Take-off Noise Characteristics of the Caravelle Jet Airliner and of Conventional Propeller-Driven Airliners. Laymon N. Miller and Leo L. Beranek. *ASA J.*, Nov., 1957, pp. 1,169–1,179. (Also in *Noise Control*, Nov., 1957, pp. 42–47, 70.) Evaluation based on three factors: relative noise levels, duration of noise, and frequency distribution of noise. Noise level measurements are made under the take-off path at various distances from the beginning of the take-off runway.

Aerodynamics

Boundary Layer

Aerodynamic Effects of Boundary Layer Unsteadiness. Franklin K. Moore. *Anglo-Am. Aero. Conf., 6th, Folkestone, Sept. 9-12, 1957, Paper.* 35 pp. 31 refs. Review of the boundary-layer theory for a flat plate moving with a time-dependent velocity. Includes analysis of airfoil lift hysteresis.

An Approximation of the Boundary of a Supersonic Axisymmetric Jet Exhausting Into a Supersonic Stream. E. S. Love. *J. Aero. Sci.*, Feb., 1958, pp. 130, 131. Description of the method proposed for flows with local, sufficiently high Mach Numbers on either side of the boundary layer to permit use of shock expansion techniques.

On Laminar Separation Bubbles. Kenneth R. Cramer. *J. Aero. Sci.*, Feb., 1958, pp. 143, 144. Analysis of leading-edge separation bubbles, and their effects on the downstream boundary layer and the airfoil lift characteristics.

Increased Usable Lift Through Boundary Layer Control. Charles W. Harper. *Anglo-Am. Aero. Conf., 6th, Folkestone, Sept. 9–12, 1957, Paper.* 28 pp. Discussion of boundary-layer control principles, and presentation of results from applications to wind-tunnel models and F-86 aircraft.

Control Surfaces

Some Early Jet Flap Experiments. N. A. Dimmock. *Aero. Quart.*, Nov., 1957, pp. 331–345. Presentation of some "second stage" two-dimensional experiments, along with some comments on the results.

Preliminary Analysis for a Jet Flap System in Two-Dimensional Inviscid Flow. E. C. Maskell and S. B. Gates. *Gt. Brit., ARC CP 359*, 1957. 23 pp. BIS, New York, $0.63. Establishment of some properties for a thin jet, and presentation of some momentum theorems connected with a jet issuing from a body in a uniform field of flow.

Fluid Mechanics & Aerodynamic Theory

A Method for Solving Problems of Irrotational Gas Flow by Means of High-Speed Digital Computers. Toyoki Koga. *(ASME Summer Conference, Berkeley, Calif., June 13–15, 1957, Paper 57—APM-43.) J. Appl. Mech.*, Dec., 1957, pp. 497–500. Description of the method for a bidimensional case, as well as presentation of an example.

Flow with Exchange of Mass, Momentum and Energy. J. Litwinsizyn. *Acad. Pol. Sci. Bul.*, No. 4, 1957, pp. 221–226.

Experimentelle Untersuchungen an Kármánschen Wirbelstrassen. Rudolf Frimberger. *ZFW*, Dec., 1957, pp. 355–359. 10 refs. In German. Presentation of test results for Kármán vortex streets, from measurements in water channels and wind tunnels, particularly behind circular cylinders. In the case of wind-tunnel measurements, the characteristic vortex-street quantities are measured up to Reynolds Numbers of 2.5×10^6, using the hot-wire method.

On the Spectrum of Natural Oscillations of Two-Dimensional Laminar Flows. D. Grohne. *U.S., NACA TM 1417*, Dec., 1957. 34 pp. 13 refs. Analysis of the whole spectrum of the characteristic values and of the shape of the natural oscillation of the stability of laminar flows.

Motion of a Laminar Twisting Stream of Incompressible Fluid Along the Surface of a Cone. L. A. Vulis and V. P. Kashkarov. *Sov. Phys. - Tech. Phys.*, Oct., 1957, pp. 2,612–2,615. Derivation of the velocity profile (longitudinal and rotating components) for first approximation, corresponding to self-simulated motion.

Estimating Aerodynamic Characteristic Times in Hypersonic Flow. Sinclaire M. Scala. *J. Aero. Sci.*, Feb., 1958, pp. 131, 132.

Some Remarks on the Foundations of Piston Theory and Supersonic-Hypersonic Similarity. G. A. Bird. *J. Aero. Sci.*, Feb., 1958, pp. 138, 139.

The Impact of a Shock Wave on a Movable Wall. R. F. Meyer. *J. Fluid Mech.*, Dec., 1957, pp. 309–323. Derivation of an approximate solution for the one-dimensional motion following the impact of a shock wave on a wall which is free to move.

On Fully-Dispersed Shock Waves in Carbon Dioxide. Wayland C. Griffith and Anne Kenny. *J. Fluid Mech.*, Dec., 1957, pp. 286–288. Theoretical and experimental investigation showing that within a narrow speed range, from shock Mach Number of 1.00 to 1.042, shocks are fully dispersed. Such waves are observed experimentally using a shock tube and interferometer.

Response of Nonlinearly Supported Spherical Boundaries to Shock Waves. M. L. Baron. *(ASME Summer Conference, Berkeley, Calif., June 13–15, 1957, Paper 57-APM-12.) J. Appl. Mech.*, Dec., 1957, pp. 501–505. ONR-sponsored development of a nonlinear equation, solved numerically for a set of parameters.

Hypersonic Conical Shocks for Dissociated Air in Thermodynamic Equilibrium. Saul Feldman. *Jet Propulsion*, Dec., 1957, pp. 1,253–1,255. USAF-sponsored investigation and solution of the conical shock equation for an incompressible fluid downstream of the shock.

Internal Flow

The Flow Through Short Straight Pipes in a Compressible Viscous Stream. Appendix I—Note on the Characteristics of Non-Viscous, Compressible Flow in Straight Pipes of Monotonic Taper. Appendix II—Critical Length/Radius Ratio for Parallel Pipes in Viscous Flow. J. Seddon. *Gt. Brit., ARC CP 355* (Apr., 1955) 1957. 33 pp. BIS, New York, $0.90. Presentation of curves for determining the maximum length/radius ratio of a parallel pipe which will permit supersonic internal flow, in terms of the Mach Number of the stream and Reynolds Number of the pipe. The curves are given for both laminar and turbulent internal boundary layers.

The Flow of Swirling Water Through a Convergent-Divergent Nozzle. A. M. Binnie, G. A. Hookings, and M. Y. M. Kamel. *J. Fluid Mech.*, Dec., 1957, pp. 261–274. Experimental investigation using Perspex nozzles, arranged to discharge vertically downwards and in which the convergent part is followed by a short divergency. Results show that at low swirls the flow is unstable.

Stability & Control

Three-Degree-of-Freedom Evaluation of the Longitudinal Transfer Functions of a Supersonic Canard Missile Configuration Including Changes in Forward Speed. Ernest C. Seaberg. *U.S., NACA TN 4192*, Dec., 1957. 29 pp. 11 refs. Presentation of data obtained from previous flight tests in order to include the variation of the drag coefficient with angle of attack and the variation of the force and moment coefficients with velocity.

"Mixed" Motions. John M. Schuler. *Res. Trends (Cornell Aero. Lab.)*, Fall, 1957, pp. 5–7. Discussion of the problems in inertia coupling and aerodynamic coupling of aircraft with long fuselages and stubby wings, and review of the theory developed to solve such problems.

A Remark on Stability Equations. Erich Sponder. *J. Aero. Sci.*, Feb., 1958, pp. 129, 130. Consideration of the equations for the simplified case of a purely yawing aircraft, without any drag, thrust, or side force.

Wings & Airfoils

Measurement of Aerodynamic Forces for Various Mean Angles of Attack on an Airfoil Oscillating in Pitch and on Two Finite-Span Wings Oscillating in Bending with Emphasis on Damping in the Stall. Appendix A—Effects of Leading-Edge Conditions on Aerodynamic Damping for Airfoil Oscillating in Pitch. Appendix B—Some Observations on Time Histories of Individual Pressures on an Oscillating Airfoil Near Stall. Appendix C—Some Remarks Concerning Nonlinearities in Aerodynamic Forces. Appendix D—Development of Data-Reduction Relations for Finite-Span Wings Oscillating in First Bending Mode. A. Gerald Rainey. *U.S., NACA Rep. 1305*, 1957. 33 pp. 18 refs. Supt. of Doc., Wash., $0.40.

Aerodynamic Force Characteristics of Delta Wings at Supersonic Speeds. Seymour Lampert. *CIT Jet Propulsion Lab. Rep. 20-82*, Sept. 9, 1954. 43 pp. 23 refs. Experimental investigation carried out in 12- and 20-inch, flexible throat wind tunnels, to check the reliability of existing linearized-wing theory.

The Area Rule. K. Oswatitsch. *Appl. Mech. Rev.*, Dec., 1957, pp. 543–545. 20 refs. Review of the available literature on the area rule.

Aeroelasticity

An Appraisal of Aeroelasticity in Design, with Special Reference to Dynamic Aeroelastic Stability. Martin Goland. *Anglo-Am. Aero. Conf., 6th, Folkestone, Sept. 9–12*, 1957, *Paper*. 24 pp. 11 refs. Survey of the current progress in flutter engineering in the light of design needs, assessed in terms of the progress in flutter dynamics, aerodynamics, and structures.

Nonlinear Oscillations. Karl Klotter. *Appl. Mech. Rev.*, Nov., 1957, pp. 495–498. 67 refs. Survey of the literature dealing with nonlinear oscillations.

Fatigue Loadings in Flight-Loads in the Tailplane of a Comet I. Anne Burns. *Gt. Brit., ARC CP 363*, 1957. 19 pp. BIS, New York,

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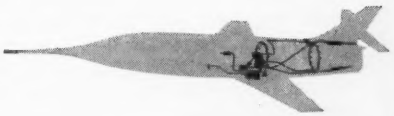

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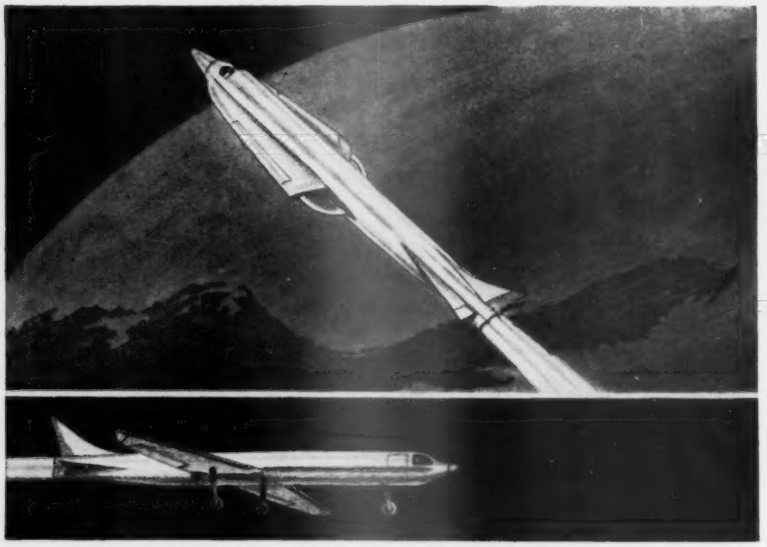

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$0.54. Experimental investigation under conditions including flight in turbulence, take-off, landing, taxiing, and ground running of the engine; and discussion of the results.

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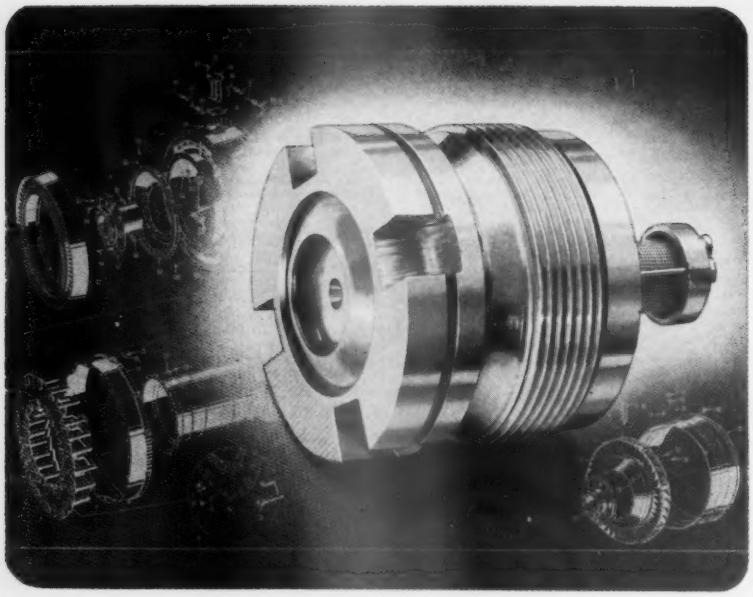

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the analysis of synchronously tuned antenna networks for transmitter frequency modulation. Includes the determination of the fundamental circuit characteristics and qualitative calculations.

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(*Continued on page 100*)

INTERNATIONAL AERONAUTICAL ABSTRACTS

A Review of Worldwide Scientific and Technical Literature

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ACOUSTICS, SOUND, & NOISE

NEAR FIELD JET NOISE. M. O. W. Wolfe. Gt. Brit., RAE TN Struc. 228, Sept., 1957. 43 pp. Measurements of jet noise in relation to its effects on aircraft structure for a range of jet shear velocities on two representative turbojet engines, one of them operating with an afterburner. Contours of equal noise pressure in the horizontal plane containing the axis of the jet are presented for noise pressures in 1/3 octave frequency bands. It is shown that for the velocity range of 790 to 1, 800 feet per second, 400 c.p.s. is the dominant frequency; at most velocities the noise pressures at this frequency are about 10 decibels less than the corresponding overall noise pressure, and the increase in noise level due to reheat is not as great as has been predicted.

AERODYNAMICS

Aerothermodynamics

ON HEAT TRANSFER IN LAMINAR BOUNDARY-LAYER FLOWS OF LIQUIDS HAVING A VERY SMALL PRANDTL NUMBER. G. W. Morgan, A. C. Pipkin, and W. H. Warner. J. Aero. Sci., Mar., 1958, pp. 173-180. ONR-sponsored analysis based on the observation that, for very small Prandtl Number, the viscous boundary layer is much narrower than the thermal boundary layer, so that the velocity distribution is essentially potential over most of the thermal layer. A solution is obtained for the first two terms of a series representation for the temperature, for arbitrary potential flow and wall temperature. This general solution is applied to the calculation of the wall temperature gradient for wedge flows with wall temperature varying as a power of the distance from the leading edge, as well as of the recovery temperature for the case of zero heat transfer. The flat plate with constant wall temperature and the insulated flat plate are considered as special cases.

CHEMICAL RELAXATION IN AIR, OXYGEN AND NITROGEN. M. Camac, J. Camm, S. Feldman, J. Keck, and C. Petty. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 802. 15 pp. Members, $0.50; nonmembers, $0.85. Experimental investigation of air kinetics using three methods: the "Ultra-Violet Absorption", the "Radiative Relaxation", and the "Mach Wave" methods. Results show that dissociation relaxation times observed for air are faster than those for O_2 and N_2; argon is only about one tenth as efficient as O_2 in producing either vibrational excitation in O_2 or for the dissociation of O_2; "Mach Wave" and "Radiative Relaxation" reaction rates are in bad agreement. It is suggested that the latter fact is due to the use of equilibrium arguments to relate the dissociation and recombination rate constants, and the importance of making direct measurements of both rates to illuminate this point is emphasized.

THE TEMPERATURE HISTORY IN A THICK SKIN SUBJECTED TO LAMINAR HEATING DURING ENTRY INTO THE ATMOSPHERE. G. W. Sutton. Jet Propulsion, Jan., 1958, pp. 40-45. Determination of the temperature distribution in closed form by integrating the product of laminar aerodynamic heating rate and the appropriate Green's function for a finite-thickness wall over the generalized trajectory for a vehicle entering the earth's atmosphere at high speeds. The maximum temperature occuring during the generalized entry trajectory for any combination of wall thickness and thermal properties is given by a single dimensionless curve. The performance of any material can then be determined, provided the average thermal properties may be used. As an example, the performance of copper, graphite, molybdenum, and tungsten are compared.

ON REDUCING AERODYNAMIC HEAT TRANSFER RATES BY MAGNETOHYDRODYNAMIC TECHNIQUES. Appendix A - THE VISCOUS STAGNATION POINT BOUNDARY LAYER EQUATIONS.

Appendix B - EQUATIONS FOR THE INVISCID OUTER FLOW AT A TWO-DIMENSIONAL STAGNATION POINT. R. C. Meyer. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 816. 15 pp. Members, $0.50; nonmembers, $0.85. Study on the modification of the flow both within and external to the viscous boundary layer. It is concluded that the primary mechanism which serves to reduce the heat transfer is an alteration of the inviscid flow external to the boundary layer. A preliminary analysis of the outer flow is presented, which provides a conservative estimate of this reduction and shows that at Mach Number 25 and at 100,000 feet altitude the heat transfer may be decreased approximately 20% for an applied field strength of eight kilogauss. The existence of an inviscid magnetic-fluid boundary layer is indicated for fluids of high electrical conductivity. On the basis of a cursory examination it does not seem practicable to significantly reduce the aerodynamic heating load on flat plates by magnetic techniques unless the electrical conductivity of air is artificially enhanced.

THE INFLUENCE OF SURFACE INJECTION ON HEAT TRANSFER AND SKIN FRICTION ASSOCIATED WITH THE HIGH-SPEED TURBULENT BOUNDARY LAYER. M. W. Rubesin. US, NACA RM A55L13, Feb. 20, 1956. 16 pp. Correlation of existing analyses on the effect of distributed surface injection to eliminate the effects of Mach and Reynolds Numbers. Data for heat transfer and skin friction at Mach Numbers of zero, 2.0, and 2.7 are compared with the analyses and the agreement is rather good. From an example employing evaporative cooling with water, it is concluded that at high Mach Numbers transpiration cooling is much more effective than conventional convective cooling.

MASS-TRANSFER COOLING OF A LAMINAR BOUNDARY LAYER BY INJECTION OF A LIGHTWEIGHT FOREIGN GAS. E. R. G. Eckert, P. J. Schneider, A. A. Hayday, and R. M. Larson. Jet Propulsion, Jan., 1958, pp. 34-39. ARDC-sponsored presentation of analytical predictions for the development of the velocity, temperature, and concentration in a laminar air boundary layer on a flat plate in high-speed dissipative flow, the plate being considered porous and cooled by injection of hydrogen from its surface. The admixture of hydrogen, having a low density and high thermal capacity relative to air, is shown to greatly diminish the skin friction and to markedly relieve the adverse thermal effects of intense aerodynamic heating under conditions of hypersonic flow.

A SIMPLE DERIVATION OF LIGHTHILL'S HEAT TRANSFER FORMULA. H. W. Liepmann. J. Fluid Mech., Jan., 1958, pp. 357-360. Analysis showing that a simple argument based on the use of the energy integral equation of the laminar boundary layer permits the derivation of a heat transfer formula valid for nonuniform temperature distribution and non-zero pressure gradients. The formula is then shown to be identical in structure with Lighthill's results. It is also shown that the approach can be slightly modified to permit application of the formula to flow near separation. The latter result is applied to the Falkner-Skan solution for just separating flows and is found to be in agreement with the exact solutions.

Boundary Layer

AN APPROXIMATE SOLUTION OF LAMINAR BOUNDARY LAYER EQUATIONS BY MEANS OF POLYNOMIALS. Jan Rościszewski. Arch. Mech. Stosowanej, No. 4, 1957, pp. 381-393. Investigation of a steady plane laminar incompressible flow in a boundary layer for a body with small curvature, governed by Prandtl equations. The separation point is calculated and results are compared with experimental data. The method used can be generalized, assuming polynomials of higher degrees and taking additional boundary conditions from Prandtl's equations or experiments. It can also be extended to include the boundary layer in an axially symmetric flow if the Kármán momentum integral is replaced by an integral condition for the boundary layer of a body of revolution.

SOME PROPERTIES OF BOUNDARY LAYER FLOW DURING THE TRANSITION FROM LAMINAR TO TURBULENT MOTION. S. Dhawan and R. Narasimha. J. Fluid Mech., Jan., 1958, pp. 418-436. 29 refs. Study of transition in the boundary layer on a flat plate from the point of view of intermittent production of turbulent spots. On the hypothesis of localized laminar breakdown, for which there is some experimental evidence, Emmons' probability calculations can be extended to explain the observed statistical similarity of transition regions. Application of these ideas allows detailed calculations of the boundary layer parameters including mean velocity profiles and skin friction during transition. The mean velocity profiles belong to a universal one-parameter family with the intermittency factor as the parameter. From an examination of experimental data the probable existence of a relation between the transition Reynolds Number and the rate of production of the turbulent spots is deduced.

URAVNENIE POGRANICHNOGO SLOIA I GRANICHNYE USLOVIIA K NIM V SLUCHAE DVIZHENIIA V SLABO RAZREZHENNOM GAZE SO SVERKHZVUKOVYMI SKOROSTIAMI. Iu. P. Lun'kin. Prikl. Mat. i Mekh., Sept.-Oct., 1957, pp. 597-605. 11 refs. In Russian. Derivation of boundary-layer equations and of boundary conditions for the case of motion in a lightly rarefied gas at supersonic velocities. The derived equations are based on Prandtl's theory and differ slightly from the ordinary Prandtl equations by the presence of complementary terms having higher velocity and temperature derivatives. The normal pressure gradient is not equal to zero and is expressed through the complementary terms. The kinetic theory is used to determine the boundary conditions, which represent a generalization of the Maxwell

and Smokhulovsky conditions for the case of motion at supersonic velocities. Limitations of the application of these equations are outlined.

PRIMENENIE METODA MALYKH VOZMUSHCHENII K ZADACHAM LAMINARNOGO POGRANICHNOGO SLOIA. V. V. Lunev. Prikl. Mat. i Mekh., Sept.-Oct., 1957, pp. 606-614. In Russian. Application of the method of small perturbations to problems of laminar boundary layers. Derivation of a solution for the boundary-layer equations of a compressible gas with small pressure gradients, and a variable Prandtl Number, and whose viscosity depends arbitrarily on temperature. The dissociation of air does not introduce any variations into the method of solution. The results are applied to the supersonic boundary layer on thin bodies or bodies differing little from a wedge or a cone.

A METHOD FOR COMPUTING THE TURBULENT BOUNDARY LAYER WHEN A LONGITUDINAL PRESSURE GRADIENT IS PRESENT. K. K. Fediaevskii and A. S. Ginevskii. Sov. Phys. - Tech. Phys., Feb., 1957, pp. 275-291. 13 refs. Translation. Development of the method which can also be used for determining the value of the local friction coefficient and the breakaway point as a result of a first approximation. Graphical representations of the resistance law indicate that special regimes, accompanied by an extremely sharp decrease in the local friction coefficient for an insignificant increase in the Reynolds Number, can possibly occur. It is shown that theory and experiment are in a satisfactory agreement.

TURBULENT BOUNDARY LAYER ON A YAWED CONE IN A SUPERSONIC STREAM. Appendix - SELECTION OF DOMINANT STRESS TERMS. W. H. Braun. US., NACA TN 4208, Jan., 1958. 39 pp. 22 refs. Derivation of the momentum integral equations for the boundary layer on an arbitrary curved surface, using a streamline coordinate system. Computations of the turbulent boundary layer on a slightly yawed cone are made for a Prandtl Number 0.70, wall to free-stream temperature ratios of 1/2, 1, and 2, and Mach Numbers from 1 to 4. Deflection of the fluid in the boundary layer from outer stream direction, local friction coefficient, displacement surface, lift coefficient, and pitching-moment coefficient are presented.

FURTHER SPACE-TIME CORRELATIONS OF VELOCITY IN A TURBULENT BOUNDARY LAYER. A. J. Favre, J., J. Gaviglio, and R. J. Dumas. J. Fluid Mech., Jan., 1958, pp. 344-356. 11 refs. Experimental investigation of the turbulent boundary layer having a zero pressure gradient. Measurements of autocorrelation and of space-time double correlation have been made respectively with single hot-wires and with two hot-wires having the separation vector in any direction. Space time correlations reach a maximum for some optimum delay. In the case of two points set on a line orthogonal to the plate, the optimum delay T_i is not zero. In the general case it is equal to the corresponding delay T_i, increased by compensating delay for translation with the mean flow. Space time isocorrelation surfaces obtained with optimum delay have a large aspect ratio in the mean flow direction, even if they are relative to a point close to a wall; the correlations along the mean flow then retain high values because of the large scale of the turbulence.

THE MINIMUM REYNOLDS NUMBER FOR A TURBULENT BOUNDARY LAYER AND THE SELECTION OF A TRANSITION DEVICE. J. H. Preston. J. Fluid Mech., Jan., 1958, pp. 373-384. Investigation based on the case of flow in a pipe, for which there is a lower experimental number to the Reynolds limit in which fully developed turbulent flow occurs. From the similarity and close agreement of the curves showing the coefficient of skin friction c_f as a function of the Reynolds number R_θ (based on the momentum thickness θ) for the circular pipe, it is suggested that there should be a lower limit to R_θ for fully developed turbulent flow on a flate plate. Limited experimental data confirm this and place the lower limit at $R_\theta = 320$.

PRIBLIZHENNYI METOD INTEGRIROVANIIA URAVNENII NESTATSIONARNOGO LAMINARNOGO POGRANICHNOGO SLOIA V NESZHIMAEMOI ZHIDKOSTI. L. A. Rozin. Prikl. Mat. i Mekh., Sept.-Oct., 1957, pp. 615-623. In Russian. Development of an approximate method of integration for the equations of a nonstationary laminar boundary layer in an incompressible fluid. The solution is based on the equations of momentum and a certain one-parametric family of velocity profiles. The applications of this method of solution to stationary problems are outlined.

LOW-SPEED BOUNDARY-LAYER-CONTROL INVESTIGATION ON A THIN RECTANGULAR SEMISPAN WING WITH LEADING-EDGE AND TRAILING-EDGE FLAPS. D. R. Croom and T. R. Turner. US, NACA RM L57J15, Jan. 20, 1958. 213 pp. Presentation of results of a wind-tunnel investigation to determine the longitudinal aerodynamic characteristics and the chordwise load distribution on a thin, untapered, unswept semispan wing having an aspect ratio of 3.33 and NACA 65A004 airfoil sections. Boundary-layer control is obtained by blowing air over the trailing-edge flaps.

Control Surfaces

THE JET-FLAPPED WING IN TWO- AND THREE-DIMENSIONAL FLOW. W. F. Jacobs and J. H. Paterson. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 791. 27 pp. 35 refs. Members, $0.65; nonmembers, $1.00. Calculation of the lift, moment, center of lift, and aerodynamic center over a large range of jet coefficients (0 to 5) and flap angles (0 to 90°). A com-

parison of measurements with the theory shows good agreement not only in the lift but also in the pitching moment. Investigations of the influence of nose modifications such as droop nose, leading edge flaps, and slats on the moment indicate that the high nose-down pitching moment at high jet coefficients can be partly compensated. A method for calculating three-dimensional effects is developed; and the results of calculations for lift, lift distributions, and induced drag are given for selected values of aspect ratio and taper ratio, as well as for selected spanwise variations of jet momentum.

Fluid Mechanics & Aerodynamic Theory

DYNAMICS OF A DISSOCIATING GAS. III - NON-EQUILIBRIUM THEORY. N. C. Freeman. (NATO AGARD 11th Wind Tunnel & Model Testing Panel, Scheveningen, July 8-12, 1957.) NATO AGARD Rep. 133, July, 1957. 21 pp. Extension of Lighthill's equilibrium theory to non-equilibrium thermodynamic conditions, and study of the behavior of gas flow through strong normal shock waves and past blunt bodies under such conditions.

CRITICAL STUDY OF THE ADEQUACY OF INTEGRAL METHODS IN PLANE MIXING PROBLEMS. L. G. Napolitano. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep.425 (AFOSR TN 57-757) [AD 136746], Dec., 1957. 66 pp. 15 refs. Presentation of solutions of plane isobaric homogeneous mixing by integral methods, depending primarily on the solution of a second-order algebraic equation. Incompressible and compressible, laminar and turbulent cases are shown to be reducible to the solution of a unique laminar-incompressible-type system of equations. It is shown that the third boundary condition, to be imposed on the y-component of the velocity, is inessential. Sixth degree polynomials satisfying second order continuity throughout the flow field and fourth order continuity at the outer edges of the dissipative region are used. Quantities of the flow field are expressed in terms of a single parameter which, in turn, depends upon the solution of a single quadratic algebraic equation. Results are compared with those obtained by other methods. The comparison shows that the present method yields the best overall accuracy.

ON THE HYDRODYNAMIC STABILITY OF CURVED LAMINAR COMPRESSIBLE FLOWS. M. Lessen. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 812. 11 pp. Members, $0.50; nonmembers, $0.85. Examination of the stability with respect to inviscid Taylor-Görtler type disturbances. It is found that flow field as well as boundary layer instabilities may exist. Contrary to the Görtler results it is shown that for the compressible case the boundary layer along a convex wall may become unstable with sufficient cooling at the wall. For the case of a curved flow field behind a curved front with uniform flow before the shock, flow field instabilities of the Taylor-Görtler type may exist. It is further shown that, with regard to boundary layer flows on flat plates, instabilities of the Taylor-Görtler type may manifest themselves before the Tollmien-Schlichting instabilities, if sufficient cooling at the boundary is present.

THE SUPERSONIC BLUNT-BODY PROBLEM – REVIEW AND EXTENSION. M. D. Van Dyke. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 801. 15 pp. 47 refs. Members, $0.50; nonmembers, $0.85. Survey of existing analytical treatments which indicates that none is adequate for predicting the details for the flow field. Reasons are given for the failure of various plausible approximations. A numerical method is developed for solving the full inviscid equations using a medium-sized electronic computer. Results are shown for a number of solutions of bodies supporting detached shock waves described by conic sections.

THE CALCULATION OF THE PATHS OF VORTICES FROM A SYSTEM OF VORTEX GENERATORS, AND A COMPARISON WITH EXPERIMENT. J. P. Jones. Gt. Brit., ARC CP 361, 1957. 16 pp. BIS, New York, $0.54. Description of the method which can be applied to other configurations of generators arranged to produce rows of vortices close to a plane surface. The theory is in fairly good agreement with experiment, except for the minimum height of the vortices.

FLOW PAST A FLAT PLATE AT LOW REYNOLDS NUMBERS. E. Janssen. J. Fluid Mech., Jan., 1958, pp. 329-343. 13 refs. Investigation by an analogue method of flow past a flat plate at Reynolds Numbers in the range of 0.1 to 10.0. The solution gives the stream function and the vorticity in the flow field surrounding the plate. From these are obtained the local coefficient of friction, the pressure distribution along the plate, and the total drag coefficient. The drag coefficient approaches the analytical values of Haaser and of Tomotika and Aoi as the Reynolds Number decreases toward 0.1; it approaches the Blasius solution as the Reynolds Number increases. At Reynolds Number 10.0 the drag coefficient is still above the Blasius value, but below the value obtained experimentally by Janour.

AN APPROXIMATE METHOD OF DETERMINING AXISYMMETRIC INVISCID SUPERSONIC FLOW OVER A SOLID BODY AND ITS WAKE. Sin-I Cheng. J. Aero. Sci., Mar., 1958, pp. 185-193. Development of an approximate method which is shown to be very satisfactory for pointed ogive bodies, and which may be applied with reasonable assurance to other curved, pointed-nose convex bodies with axisymmetric inviscid flow fields in flow regions with streamlines either diverging from or converging toward the axis of symmetry. The result of the approximate method is insensitive to the arbitrary factors implicit in the method.

XUM

COLLECTION OF ZERO-LIFT DRAG DATA ON BODIES OF REVOLUTION FROM FREE-FLIGHT INVESTIGATIONS. W. E. Stoney, Jr. US, NACA TN 4201, Jan., 1958. 373 pp. 32 refs. Summary of flight-test results for fin-stabilized bodies of revolution. Supplementary data are provided to facilitate the determination of the body pressure drags from the measured total drags. The Mach Number ranges extend from 0.6 to approximately 2.0, and the Reynolds Numbers based on body length are from 2×10^6 to 100×10^6.

CALCULATIONS BY THE METHOD OF CHARACTERISTICS. R. D. Linnell. Aero. Eng. Rev., Mar., 1958, pp. 39-44. Presentation of a high-speed electronic computer program for the calculation of axially symmetric flow around bodies of revolution by the method of characteristics. The capabilities of electronic computers are considered in the reduction of differential equations of the method to difference equations. Special attention is given to the extensive logic required, and it is shown that the important logic portion of the program is based upon the capabilities of electronic computers as well as upon a knowledge of aerodynamic phenomena.

ISSLEDOVANIE SVERKHZVUKOVYKH TECHENII S POMOSHCH'IU INTEGRALA VOL'TERRA. A. I. Utkin. AN SSSR Dokl., Sept. 21, 1957, pp. 369-372. In Russian. Application of the Volterra integral to investigate the linear problem of supersonic flow around axisymmetric profiles. The integral is reduced to a second-order linear integral equation which can be solved by means of operational calculus. The problem of an annular-wing profile with minimum wave drag is used to illustrate a case of practical application, and the shape of the source-sink area is determined in the case of given pressure.

SLOW MOTION OF A PARABOLOID OF REVOLUTION IN A ROTATING FLUID. L. V. K. Viswanadha Sarma. J. Fluid Mech., Jan., 1958, pp. 404-410. Investigation using a perturbation method for uniform motion, after an impulsive start from relative rest, of a paraboloid of revolution along the axis of a rotating fluid. It appears that the flow is an oscillatory one in which the distance between any fluid particle and the axis of rotation oscillates sinusoidally in time with small amplitude. As time progresses, the amplitude of the oscillation decays to zero everywhere except on the paraboloid. The ultimate motion is then a rigid body rotation everywhere except on the paraboloid and the axis of rotation, where the perturbation velocities continue to oscillate indefinitely with small amplitude.

EXAMPLES OF DETACHED BOW SHOCK WAVES IN HYPERSONIC FLOW. P. R. Garabedian and H. M. Lieberstein. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 817. 21 pp. 14 refs. Members, $0.65; nonmembers, $1.00. ONR-sponsored description of a method for calculating the flow past a bluff axially symmetric body, assuming the shock wave form. The analysis is based on a Cauchy problem for the stream function in the subsonic region, where the motion is governed by a partial differential equation of the elliptic type. Through analytic continuation into the complex domain, the Cauchy problem is reformulated in such a manner that it becomes properly set in the subsonic region, leading to a stable scheme for computation of the flow by finite differences. Numerical examples at free-stream Mach Number 5.8 are presented in which the flow is determined throughout the subsonic region, and, in particular, the detachment distance, the location of the sonic line, and the pressure distribution along the body are calculated. These results are in excellent agreement with experimental data.

UDARNYE VOLNY BOL'SHOI AMPLITUDY V GAZAKH. Ia. B. Zel'dovich and Iu. P. Raizer. Uspekhi Fiz. Nauk, Nov., 1957, pp. 613-641. 74 refs. In Russian. Survey of various physical processes in the shock-wave front and evaluation of their influence on the inner structure of the front. Particular emphasis is placed on the radiation and absorption of light and the radiative heat tranfer over the front, which mainly determine the front pattern and thickness in the case of a large-amplitude shock wave, as well as its intensity.

STUDIES ON THE LOW SUPERSONIC FLOW WITH A DETACHED SHOCK (AN ANALYTIC DETERMINATION OF THE FLOW AROUND A SPHERE WITH A DETACHED CURVED SHOCK). Jiro Kondo. Japan Soc. Aero. Eng. J., Dec., 1957, pp. 1-4. In Japanese. Extension of a theoretical and experimental analysis of two-dimensional flow around a body with a detached shock to the case of three-dimensional axially symmetric flow. The stream function of the flow pattern behind the detached shock is expressed with several parameters, the simultaneous linear equations of which are introduced by the shock conditions on some points on the shock, determined by schlieren or shadow photographs of the high speed flow. A particular example of free-stream Mach Number 1.49 around a sphere is presented (four-parameter approximation), and the density and pressure variations along the axis and on the surface near the forward stagnation point are obtained.

ON THE STATISTICAL THEORY OF TURBULENCE. W. Heisenberg. (Zeitschrift für Physik, vol. 124, 1948, pp. 628-657.) US, NACA TM 1431, Jan., 1958. 36 pp. 14 refs. Translation. Study of the spectrum of isotropic turbulence using a Fourier analysis. The spectrum of the turbulent motion is derived to the smallest wavelengths in the laminar region, and correlation functions and pressure fluctuations are calculated. Comparison is made with experimental results. An attempt is also made to derive the numerical value of a constant characteristic of the energy dissipation in isotropic turbulence.

Internal Flow

PERFORMANCE OF A SUPERSONIC COMPRESSOR WITH SWEPT AND TILTED DIFFUSER BLADES. A. W. Goldstein and R. L. Schacht. US, NACA RM E54L29, Mar. 28, 1955. 32 pp. Investigation of a 14-inch supersonic mixed-flow compressor of large weight-flow capacity over a range of equivalent air tip speeds varying from 740 to 1,700 feet per second. As rotor speed is increased over the entire range, stage efficiency decreases continuously from 73% to 47 % and pressure ratio reaches a value of 5.02. Measurements are made of static-pressure distributions, overall performance, and of the magnitude, frequency, and rotative speed of pressure fluctuations, which are found to be very large and believed to prevent the stator from attaining the flow configuration for which it is designed.

LOW-SPEED CASCADE INVESTIGATION OF COMPRESSOR BLADES HAVING LOADED LEADING EDGES. J. C. Emery. US, NACA TN 4178, Jan., 1958. 76 pp. Investigation of blade cambers having isolated-airfoil lift coefficients of 0.6, 1.2, 1.8, and 2.4 over the usable angle-of-attack range for inlet-air angles of 30°, 45°, and 60° at solidities of 1.0 and 1.5. A comparative evaluation is presented of the results of this and previous cascade investigations of compressor blades having uniform chordwise loading as isolated airfoils and those having more loading at the trailing edge.

ÜBER DIE INSTATIONÄRE ÜBERSCHALLSTRÖMUNG DURCH SCHAUFELGITTER MIT RÜCKWIRKUNG. I. Ryhming. ZAMM, Nov.-Dec., 1957, pp. 416-431. In German. Investigation of the nonstationary phenomena in supersonic cascades. The problem is simplified by considering the admission stream entering a vane at large r. p.m., assuming the vanes to be straight lines and the flow to be nonviscous and nonturbulent. Boundary effects are neglected, and, as a result, the physical properties of the non-stationary flow are obtained.

THE TRANSONIC FLOW FIELD OF AN AXIAL COMPRESSOR BLADE ROW. J. E. McCune. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 792. 15 pp. Members, $0.50; nonmembers, $0.85. OSR-supported method for studying the three-dimensional field of blade rows within the linearized (acoustic) approximation. The resulting theory demonstrates a smooth transition from the subsonic to the transonic or mixed-flow regimes. It predicts the occurrence of acoustic resonance in the mixed-flow regime. Viscous damping is introduced as a method for treating cases where this phenomenon occurs. Numerical examples of the behavior of a transonic blade row are presented, and the general theory brings to light the existence of a similarity parameter which correlates certain aspects of the three-dimensional flow field.

TWO-DIMENSIONAL FLOW AT HIGH SUBSONIC SPEEDS PAST WEDGES IN CHANNELS WITH PARALLEL WALLS. J. B. Helliwell. J. Fluid Mech., Jan., 1958, pp. 385-403. Investigation of plane flow for an inviscid isentropic gas at high subsonic and low sonic speeds past a finite wedge set at zero incidence. Hodograph methods are applied to the determination of the stream function, which, under the usual transonic approximation, is a solution of Tricomi's equation. A brief summary is given on the derivation of the fundamental solution of this equation in terms of Bessel functions. Two flow pattern models are examined. Cole's model with the sonic line from the shoulder extending completely across the channel at right angles to the wall is analyzed. Also examined is the Helliwell-Mackie model in which there is a free stream breakaway at sonic velocity from the shoulder of the wedge and the velocity far downstream may be either uniformly subsonic or sonic.

CRITERIA FOR INITIAL FLOW REVERSAL IN SYMMETRICAL TWIN-INTAKE AIR-INDUCTION SYSTEMS OPERATING AT SUPERSONIC SPEEDS. Appendix - APPLICATION OF ONE-DIMENSIONAL SUBSONIC PARALLEL-JET MIXING EQUATIONS TO TWIN DUCTS. Andrew Beke. US, NACA RM E55L02a, Feb. 20, 1956. 17 pp. Study of asymmetric air-flow characteristics of air-induction systems with inlets having peak static-pressure recovery at greater than 50% mass flow and critical static-pressure recovery equal to or greater than the value at zero mass flow. Analytical predictions of asymmetric flow and initial flow reversal agree with the experimentally observed trends. Results show that initial flow reversal occurs simultaneously with critical inlet flow in the other duct. Thus, in terms of engine throttling, engine air flow cannot be reduced to less that half the total inlet critical air flow before initial flow reversal occurs.

Stability & Control

EFFECT OF FLOW INCIDENCE AND REYNOLDS NUMBER ON LOW-SPEED AERODYNAMIC CHARACTERISTICS OF SEVERAL NONCIRCULAR CYLINDERS WITH APPLICATIONS TO DIRECTIONAL STABILITY AND SPINNING. E. C. Polhamus. US, NACA TN 4176, Jan., 1958. 54 pp. 15 refs. Determination of the aerodynamic characteristics of several noncircular two-dimensional cylinders with axes normal to the stream at various flow incidences for a range of Reynolds Numbers from low-speed wind-tunnel tests. Results indicate that these parameters have rather large effects on drag and side force developed on these cylinders, the side force being especially critical and very often undergoing a change in sign with a change in Reynolds Number. The implications of the two-dimensional results with regard to directional stability of fuselages at high angles of attack are briefly discussed.

EFFECT OF ANGLE OF ATTACK AND THICKNESS ON AERODYNAMIC COEFFICIENTS OF A

RIGID WING OSCILLATING AT VERY LOW FREQUENCIES IN TWO-DIMENSIONAL SUPERSONIC FLOW. F. S. Malvestuto, Jr., and J. M. Goodwin. US, NACA TN 4069, Jan., 1958. 65 pp. Presentation of analytical expressions for the effect of angle of attack and thickness on the lift and pitching moment derivatives of a wing performing a plunging motion and rotary oscillations at very low frequencies in two-dimensional flow. Design charts are presented which permit rapid calculation of these coefficients. The results presented are for a range of Mach Number, angle of attack, and thickness for which the flow behind the shock attached to the leading edge is everywhere supersonic, although the effect of viscous separation at finite angles of attack restricts the validity of the results to a much smaller range of these parameters.

WIND-TUNNEL INVESTIGATION OF THE STATIC LONGITUDINAL STABILITY AND TRIM CHARACTERISTICS OF A SWEPTBACK-WING JET-TRANSPORT MODEL EQUIPPED WITH AN EXTERNAL-FLOW JET-AUGMENTED FLAP. Appendix - DERIVATION OF EXPRESSIONS FOR CALCULATING LONGITUDINAL-TRIM REQUIREMENTS OF SEVERAL AIRPLANE CONFIGURATIONS EQUIPPED WITH JET-AUGMENTED FLAPS J. L. Johnson, Jr. US, NACA TN 4177, Jan., 1958. 89 pp. Wind tunnel tests to determine the effects of wing position, vertical position of the horizontal tail for a range of momentum coefficients up to about 4. The model has a 30° sweptback wing with an aspect ratio of 6.60. Results show that it is necessary to locate the horizontal tail well above the chord plane of the wing and to incorporate both variable incidence and an elevator. Larger tail areas are required for the low tail position. Calculations for trim devices show the superiority at a given lift coefficient of the fixed canard surface utilizing jet augmentation for providing longitudinal trim and stability.

Wings & Airfoils

THEORETICAL PRESSURE DISTRIBUTIONS FOR SEVERAL RELATED NONLIFTING AIRFOILS AT HIGH SUBSONIC SPEEDS. J. R. Spreiter, A. Y. Alksne, and B. J. Hyett. US, NACA TN 4148, Jan., 1958. 52 pp. 27 refs. Theoretical investigation of five related airfoils, including thin symmetrical circular-arc airfoils, in two-dimensional flows with high subsonic free-stream velocity. The airfoils have various locations for the point of maximum thickness ranging from 30% to 70% chord and are of arbitrary, although small, thickness ratio. The results are obtained by approximate solution, through an iteration process, of a nonlinear integral equation derived from the equations of transonic flow theory. It is shown that the pressure distributions display most of the principal phenomena observed in experimental studies, and are in good correspondence with those calculated by other methods for subcritical Mach Numbers and for Mach Numbers near 1.

CURVES OF MINIMUM WAVE PLUS VORTEX DRAG COEFFICIENT FOR SEVERAL WING PLANFORMS. B. J. Beane. Douglas Rep. SM-22989, Nov., 1957. 7 pp. 11 refs. Presentation of curves valid for Mach Numbers of 2, 3, and 4, including values representing the wave plus vortex drag, as computed by linearized theory, for wings that are twisted and cambered such that the surface loading is optimum. Skin friction and thickness drags are not included.

DRAG REDUCTION OF THIN WINGS AT SUPERSONIC SPEEDS, BY THE USE OF CAMBER AND TWIST. G. M. Roper. Gt. Brit., RAE Rep. Aero. 2585, July, 1957. 105 pp. 43 refs. Consideration of two cases: (a) ignored leading-edge suction forces, and (b) included leading-edge suction forces. It is found that twist, especially towards the wing tips, is more effective in reducing drag, for given lift, for the larger values of $\tan\gamma/\tan\mu$, where γ is the semi-apex-angle and μ is the Mach angle, and that camber is more effective for the smaller values. In case (a) the maximum percentage drag reduction varies from about 10% to 50%, and in case (b) from zero to about 10%. A sweptback trailing edge increases, in general, the maximum percentage drag reduction for given lift if suction forces are ignored, but decreases the maximum reduction for smaller values of $\tan\gamma/\tan\mu$, and increases the maximum reduction for values of $\tan\gamma/\tan\mu$ near to one, if suction forces are applied.

THE COMPRESSIBILITY RULE FOR DRAG OF AIRFOIL NOSES. R. T. Jones and M. D. Van Dyke. J. Aero. Sci., Mar., 1958, pp. 171, 172, 180. Investigation showing that the drag of any semiinfinite airfoil section in purely subsonic inviscid flow follows precisely the Prandtl-Glauert compressibility rule. The result obtained for the parabola is applicable to leading-edge corrections in thin airfoil theory.

SUPERSONIC FLOW PAST NARROW WINGS WITH "SIMILAR" CROSS-SECTIONS AT ZERO-LIFT. W. T. Lord and G. G. Brebner. Gt. Brit., RAE TN Aero. 2509, Aug., 1957. 55 pp. 15 refs. Description and illustration of a method for designing thickness distributions for narrow wings with straight unswept trailing edges and "similar" chordwise cross-sections. The methods hold for arbitrary planform and cross-section and can be applied to more complicated configurations than simple isolated wings. Two forms of the method are presented: the first specifying the area distribution, the second specifying for each planform a geometrically simple root profile. Only the second method may be extended to wings with swept forward trailing edges. Formulas are given for the overall pressure distributions, and in particular the root pressure distributions and wave drag of such wings.

AERODYNAMICS OF BODIES, WINGS, AND WING-BODY COMBINATIONS AT HIGH ANGLES

OF ATTACK AND SUPERSONIC SPEEDS. J. N. Nielsen, J. R. Spahr, and Frank Centolanzi. US, NACA RM A55L13c, Feb. 13, 1956. 12 pp. 16 refs. Presentation of maximum lift coefficients for triangular and rectangular wings, together with some downwash measurements behind a rectangular wing at high angles of attack. A method is given to show how the body vortex strengths and positions presented by Jorgensen and Perkins can be used to predict the nonlinear panel normal forces, hinge moments, and rolling moments for cruciform-wing and body combinations at high angles of attack.

AEROELASTICITY

THEORETICAL CONSIDERATIONS OF FLUTTER AT HIGH MACH NUMBERS. H. G. Morgan, H. L. Runyan, and Vera Huckel. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 776. 19 pp. 16 refs. Members, $0.50; nonmembers, $0.85. Discussion of some of the theories for two-dimensional oscillatory air forces applicable to flutter calculations. These include linear theory, Van Dyke's second-order theory, piston theory, Landahl's method, tangent wedge and tangent cone approximations, Newtonian theory, and a new nonlinear pressure method. A comparison of the theories is made by showing the results of flutter calculations for Mach Numbers up to 10, and the possibility of flutter at these higher Mach Numbers is pointed out. Results of flutter calculations are shown to illustrate the various effects arising from a nonlinear thickness theory, and flutter speed trends with center-of-gravity and elastic-axis locations are presented; includes also a discussion of some possible refinements of piston theory.

FLUTTER OF THIN PANELS AT SUBSONIC AND SUPERSONIC SPEEDS (U). J. E. Greenspon and R. L. Goldman. Addendum - SOME EXPERIMENTS ON PANEL FLUTTER. P. F. Jordan and Edward Widmayer. Martin Rep. ER 9934 (AFOSR TR 57-65) [AD 136560], Nov., 1957. 75 pp. 23 refs. Exploratory investigation into the actual physical mechanism of skin flutter, along with a review of available theories prompted together with certain extensions. The study reveals that subsonic skin flutter is possible; this being contrary to some previous theoretical results. The subsonic and, to some extent, the supersonic flutter of finite skin panels is a periodical interchange between quasi-static shapes of the skin and is thus more complex than is assumed in any previous theory. A simple phenomenological analysis is developed, based on possible shapes (for the membrane case), giving qualitative agreement with experimental results for the subsonic case. Flutter is self-limited in amplitude and is not necessarily destructive. Panel response due to external noise may, however, be destructive.

ON TORSIONAL VIBRATIONS OF A BEAM WITH A SMALL AMOUNT OF PRETWIST. Eric Reissner and Kyuichiro Washizu. Japan Soc. Aero. Eng. J., Dec., 1957, pp. 4-9. ONR-supported investigation using a system of approximate differential equations obtained by variational methods from the theory of shallow thin shells. Application of these equations to the problem of torsional vibrations shows that a relatively small amount of pretwist may have a considerable influence on the torsional frequencies of the beam.

NORMAL MODE ANALYSIS OF BEAMS OF NON-UNIFORM CROSS-SECTION WITH TABULATED RESULTS FOR SOME LINEARLY TAPERED CLAMPED-PINNED BEAMS. Appendix A - A NUMERICAL EXAMPLE OF THE DETERMINATION OF THE EIGENVECTORS AND EIGENVALUES OF A 3 x 3 MATRIX. R. S. Julius and S. Ranta. Canada, NAE LR 210, Sept., 1957. 33 pp. Presentation of a theory for the free lateral vibrations of long beams in which the space-dependent part, a homogeneous boundary value problem, is written as an integral equation by means of Green's function, approximated by a set of n equations in matrix form. Their eigenvectors approximate the first n eigenfunctions of the integral equation. The Duncan and Collar matrix iteration process in modified form for obtaining the eigenvalues and eigenvectors is described and applied to two families of linearly tapered, clamped-pinned beams.

ÜBER DEN ZUSAMMENHANG VERSCHIEDENER NÄHERUNGSVERFAHREN ZUR BERECHNUNG NICHTLINEARER SCHWINGUNGEN. K. Magnus. ZAMM, Nov.-Dec., 1957, pp. 471-485. 11 refs. In German. Analysis showing that some approximation methods frequently used in nonlinear mechanics are special cases of the general variational method due to Ritz and Galerkin. A generalized method is derived allowing the linearization by means of nonharmonic functions. Applications are made to the cases of natural vibrations of a self-excited pendulum with one-degree-of-freedom and to forced vibrations of a nonperiodical system.

SOME STRUCTURAL RESPONSE CHARACTERISTICS OF A LARGE FLEXIBLE SWEPT-WING AIRPLANE IN ROUGH AIR. T. L. Coleman, H. N. Murrow, and H. Press. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 785. 15 pp. Members, $0.50; nonmembers, $0.85. Analysis of test measurements of aircraft motion and strain responses. Power spectral methods are employed in order to provide an indication of the frequency composition of the various responses and, in this way, to determine the contribution of the various aircraft rigid-body and elastic-body modes to the strain responses. The aircraft rigid-body motions and elastic-body motions are examined in detail in order to assess the magnitude of the aerodynamic forces arising from these motions.

EFFECTS OF A TIME-VARYING TEST ENVIRONMENT ON THE EVALUATION OF DYNAMIC STABILITY WITH APPLICATION TO FLUTTER TESTING. W. H. Reed III. IAS 26th Annual Meet-

ing, New York, Jan. 27-30, 1958, Preprint 822. 19 pp. 14 refs. Members, $0.50; nonmembers, $0.85. Discussion of the dynamic response of a system with a time-varying excitation frequency, and consideration of various frequency-sweep techniques. An analysis of the transient motion of a single-degree-of-freedom system whose damping and natural frequency change with time indicates that the apparent stability depends upon which vibration measurement is being observed. Vibration time histories of acceleration are found to be about three times as sensitive to parameter variations as are time histories of velocity and displacement. The results are applied to flutter testing, and an approximate relation is derived for the magnitude of the apparent shift in the flutter boundary due to the unsteady nature of the tests.

AIRPLANE DESIGN

SOME APPLICATIONS OF THEORETICAL AERODYNAMICS TO THE DESIGN OF HIGH PERFORMANCE AIRCRAFT. G. C. Grogan, Jr. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 787. 11 pp. 21 refs. Members, $0.35; nonmembers, $0.75. Discussion emphasizing the importance of drag reduction by comparing it with dry weight reduction, and presentation of low drag designs resulting from aerodynamic theory. These include the following: (a) several methods of designing low drag bodies of revolution, (b) two cases of designing by the supersonic area rule, (c) the design of low drag, trimmed, cambered wing surfaces, and (d) a simple example of favorable interference between volume and lifting elements.

THE MINIMUM WAVE-DRAG PROBLEM FOR THE ADDITION OF A BODY TO A GIVEN AIRPLANE CONFIGURATION. J. F. Vandrey. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 789. 15 pp. Members, $0.50; nonmembers, $0.85. Presentation of a numerical solution, based on the use of a Fourier series, for the additional wave drag caused by adding a body to a given configuration. This solution is used to determine the optimum area distribution of a body of given length, inlet and outlet area, and of given volume, which is to be added to the configuration along a certain streamline. Special cases of this general optimum problem are: (1) to reshape the central part of the fuselage of an airplane in such a way that its zero-lift wave-drag becomes a minimum, while the total volume and the two ends of the fuselage remain unchanged; and (2) to fair out the central part of the fuselage with a given front and rear ends, so that the whole airplane becomes a minimum under the circumstances, irrespective of its volume.

A METHOD OF OPTIMISING AIRCRAFT AUTOSTABILIZER SYSTEMS. J. Wolkovitch. Coll. of Aeronautics, Cranfield, Rep. 113, May, 1957. 84 pp. 19 refs. Presentation of the method applicable to piloted aircraft and including also many important nonlinear effects with only slight extra complication in the required calculations. Its essence is the assumption that the purpose of the autostabilizer is to reduce the effort demanded of the pilot in executing a given maneuver or attaining a given response. Although the presence of the pilot is explicitly taken into account in the calculations, no form of pilot's transfer function need be specified. It is shown how the procedure may be modified to form an approximate procedure for the optimization of autostabilizers for pilotless aircraft having linear autostabilizer characteristics and linear aircraft dynamics.

GROUND PERFORMANCE AT TAKE-OFF AND LANDING. D. J. Kettle. Aircraft Eng., Jan., 1958, pp. 2-4. Presentation of a chart for the rapid evaluation of either unstick or landing roll distance. The method does not deal with the airborne phase of take-off and landing maneuvers, and is strictly applicable only when wing incidence remains constant for the whole ground run. An attempt is made to relate an equivalent value of μ to touchdown speed for the standard wet and dry runway, as adopted by I.C.A.O., assuming fitted automatic brakes and a maximum braking force equal to 0.35 of the landing weight.

A THEORETICAL ANALYSIS OF THE AIRBORNE PATH DURING TAKE-OFF. W. R. Buckingham. Aircraft Eng., Jan., 1958, pp. 5-8. Linear analysis assuming that variations of the physical quantities (aircraft speed, angle between flight path and horizontal, and lift coefficient increment) are small enough for squares and higher powers of such variations to be neglected in comparison with the variations themselves. Results depend on the solutions of a pair of ordinary simultaneous linear differential equations with constant coefficients. It is shown that if the aircraft speed never falls below the unstick speed, the limiting values of the lift coefficient increment defining the safe range of take-offs can be determined, and that, by considering the mean value of the lift coefficient increment over the safe take-off range, it is possible to define a mean safe take-off and to estimate the corresponding mean safe airborne distance from the unstick point to a height of 50 feet.

FUELS & LUBRICANTS

LOW-TEMPERATURE, VAPOR-PHASE OXIDATION OF FUEL-RICH HYDROCARBON MIXTURES. W. T. House and Milton Orchin. US., NACA TN 4118, Jan., 1958. 30 pp. 17 refs. Study of the vapor-phase oxidation of methylcyclohexane in a flow system within the temperature range of 300° to 400° C under the conditions of 0.1 the stoichiometric amount of oxygen, and a contact time of eight seconds in a spiral Pyrex reactor 10.5 inches long. The yields of acids, aldehydes, ketones, hydrogen peroxide, organic peroxides, olefin, water, and unreacted hydrocarbon were determined. It was found that the yield of olefins reaches a maximum in the range of the neg-

ative temperature coefficient, that of peroxides decreases on increasing the temperature in this range, and that of other oxygenated materials steadily decreases at increasing temperatures. Dark-brown, tarry residues are obtained at the reactor exit, probably arising from condensation reactions of aldehydes and ketones.

INSTRUMENTS

A DECELERATION PROBE FOR MEASURING STAGNATION PRESSURE AND VELOCITY OF A PARTICLE-LADEN GAS STREAM. J. L. Dussourd and A. H. Shapiro. Jet Propulsion, Jan., 1958, pp. 24-34. ONR-supported theoretical and experimental investigation of stagnation pressure measurements, and development of a measuring device able to meet the following requirements: to prevent flooding from particles, and to minimize the aerodynamic interaction effects outside and inside the probe. The phenomena associated with the momentum interchanges between gas and particles are analyzed, and quantitative evaluation is made of the associated error recorded by a total pressure probe. Error magnitude is presented graphically, and theoretical findings are checked by testing a series of experimental probes of varying geometry in an air stream carrying water droplets. A satisfactory agreement is obtained, and it is shown that the probe gives a negligible error and can also be adapted to local measurements of the mass rate of flow per unit area of particles, particle size, and particle velocity.

MATERIALS

Metals & Alloys

O SVIAZI MEZHDU DIFFUSIEI I ZHAROPROCHNOST'IU V SPLAVAKH NIKELEVYKH SISTEM. I. I. Kornilov and A. Ia. Shiniaev. AN SSSR Otd. Tekh. Nauk Izv., Sept., 1957, pp. 50-55. 10 refs. In Russian. Experimental investigation of the relationship between diffusion and heat resistance of nickel-based alloys. Tests are performed on Ni-Ti, Ni-Ti-Cr, and Ni-Ti-Cr-W-Al alloys at temperatures ranging between 800° and 1,200°C. Results indicate that the diffusion coefficient has the greatest value at all temperatures in binary alloys; at temperatures up to 1,100° it has the smallest value in five-component alloys; at temperatures above 1,100° it becomes equal to the diffusion coefficient of the ternary alloy; at even higher temperatures (1,200° - 1,250°) its value becomes larger than that of ternary alloys. The results are used to calculate the value of the activation energy of the diffusion process for each alloy.

MATHEMATICS

DISCRETE POTENTIAL THEORY FOR TWO-DIMENSIONAL LAPLACE AND POISSON DIFFERENCE EQUATIONS. Appendix A - GREEN'S IDENTITIES. Appendix B - HOMOGENEOUS INTEGRAL-EQUATION ANALOG FOR NEUMANN PROBLEM. Appendix C - HOMOGENEOUS INTEGRAL-EQUATION ANALOG FOR DIRICHLET PROBLEM. Appendix D - CLASSICAL POTENTIAL THEORY. Charles Saltzer. US, NACA TN 4086, Jan., 1958. 60 pp. Presentation of a method for solving problems associated with Laplace and Poisson equations which, in general, requires considerably fewer equations than the usual methods and gives a convergent solution by the method of successive approximations. It is shown that for infinite regions, the exact solution for the Dirichlet and Neumann problems can be found by solving a system of equations with as many variables as there are boundary points of the region. It is further shown that at each stage of the iteration a best possible estimate of the error of the approximate solution with respect to the exact solution of the difference equation for the Dirichlet problem is furnished, and, for the Neumann problem, a bound for the error of the normal difference of the approximate solution is given.

APPLICATION DE LA TRANSFORMATION DE LAPLACE ET DE LA TRANSFORMATION DE HANKEL A LA DETERMINATION DE SOLUTIONS DE L'EQUATION DE LA CHALEUR ET DES EQUATIONS DE MAXWELL EN COORDONNEES CYLINDRIQUES. Huguette Delavault. France, Min. de l'Air NT 71, 1957. 99 pp. 59 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 1,500. In French. Investigation of the use of combinations of Laplace, Hankel, and Fourier transforms, using the Laplace function for time variables and the other transforms for spatial variables. The characteristics of these combined operations are described. The simultaneous use of these transforms permits to obtain the solution of problems to given limits of three or four variables. As an example two problems are analyzed: (a) heat transfer between plane surfaces and (b) propagation of electromagnetic waves in a circular cylinder with generalized wall conditions.

MISSILES

EINFLUSSGRÖSSEN BALLISTISCHER FERNFLUGKÖRPER. Oscar Scholze. Raketentech. & Raumfahrtforsch., Jan., 1958, pp. 2-8. In German. Investigation of trajectory characteristics of missiles, rocket aircraft, and satellite-carrying rockets shows that trajectories of all three are similar and therefore could be produced by the same type of propulsion. Study includes: dimensional effects, the effects of acceleration, number of stages or boost units, and air resistance. Current developmental problems are briefly summarized.

THE CALCULATION OF FUEL DISTRIBUTION IN STEP-ROCKETS. M. L. Williams. Brit. Interpl. Soc. J., Oct.-Dec., 1957, pp. 211-215. Presentation of results indicating changes in Vertregt's analysis of the rocket performance that result from considering the dry mass to be composed of three parts: load-carrying structure, non-structural weight, and power plant weight.

NAVIGATION

INERTIAL GUIDANCE FOR ROCKET-PROPELLED MISSILES. W. T. Russell. (ARS Semi-Annual Meeting, San Francisco, June 10-13, 1957.) Jet Propulsion, Jan., 1958, pp. 17-24. 14 refs. Explanation of the basic elements of inertial guidance systems, and description of precision gyroscopes, accelerometers, and stabilized platforms. Guidance schemes appropriate to ballistic missiles are discussed, and a trajectory for the German V-2 rocket is presented as an example. The problem of gravity computation is considered, and the effect of instrument errors is explored. A missile steering computer and a rocket motor shut-off computer are given for the V-2 rocket. Numerical values of coefficients are calculated for the sample trajectory.

PHYSICS

MAGNITNAIA GIDRODINAMIKA. S. I. Syrovatskii. Uspekhi Fiz. Nauk, July, 1957, pp. 247-303. 145 refs. In Russian. Analysis of the theory of magnetohydrodynamics and review of previously obtained results. Includes: derivation of basic equations; discontinuity surfaces and shock waves -- tangential discontinuity, perpendicular shock wave, magnetohydrodynamic wave, inclined shock wave; amplification of the magnetic field; stability problems -- gravitational stability, thermal convection in the magnetic field, stability of the simplest fluxes in the magnetic field; magnetohydrodynamic turbulence -- conditions of growth of the magnetic field in turbulent media, stationary-state problem, two-dimensional turbulence, application of methods of the theory of homogeneous isotropic turbulence in magnetohydrodynamics; and derivation of solutions for such problems as magnetohydrostatics, stationary solutions, magnetohydrodynamic waves of arbitrary amplitude, and nonstationary motions.

TRANSMISSION OF ELECTROMAGNETIC WAVES THROUGH IONIZED AIR SURROUNDING HYPERSONIC AIRCRAFT. Z. O. Bleviss. Douglas Rep. SM-22965, Oct., 1957. 30 pp. 16 refs. Estimation of the magnitude of the effect of ionized air on the transmission through two different regions: (a) the blunt nose region, and (b) the high-speed laminar or turbulent boundary layer on a slender afterbody. Thermodynamic equilibrium is assumed, and well-known equations for the propagation of electromagnetic waves in the ionosphere are used to study two effects: (1) attenuation of waves passing through ionized air and (2) reflection of waves as they impinge on ionized air, as functions of speed, altitude, and wave length. It is concluded that for speeds up to about 25,000 feet per second and altitudes up to 250,000 feet, vacuum wave lengths less than about one millimeter are necessary for transmission through the blunt nose region, and of about one meter for transmission through the high-speed boundary layer.

POWER PLANTS

Jet & Turbine

A THEORETICAL ANALYSIS OF REACTION RATE CONTROLLED SYSTEMS. II. Appendix I, II - EFFECT OF FUEL DISTRIBUTION ON REACTION RATES. Appendix III - HEAT LOSS RATE FROM "CAN" BURNERS. Appendix IV - PRESSURE LOSS DEPENDENCE OF "CAN" BURNERS. M. V. Herbert. Gt. Brit., NGTE Rep. R.213, Oct., 1957. 129 pp. 44 refs. Analysis in which general equations given previously are revised, leading in particular to a corrected vitiation factor in the air loading group. Theoretical predictions of loading are also made for the cases of water vapor dilution of the combustion mixture and nonuniform fuel distribution. Further analysis of data on can and baffle stabilizers clasifies the balance between reaction and aerodynamic factors. It is tentatively concluded that this balance is similar for cans with a statistical internal flow pattern and both three and properly two-dimensional baffles with fully turbulent conditions in the wake. An explanation is also given for the effect of baffle drag on stability for small blockages.

EXPERIMENTAL INVESTIGATION OF TURBOJET-ENGINE MULTIPLE-LOOP CONTROLS FOR NONAFTERBURNING AND AFTERBURNING MODES OF ENGINE OPERATION. Appendix A, B - SYSTEM RESPONSE EQUATIONS AND STABILITY STUDIES FOR DOUBLE-LOOP CONTROLS ON A TURBOJET ENGINE. D. B. Kirsch, L. M. Wenzel, and C. E. Hart. US, NACA TN 4159, Jan., 1958. 61 pp. Determination of the mode of control required for obtaining optimum rotor speed and turbine-discharge temperature transient response characteristics during thrust increase and afterburner ignition. Good engine transient performance characteristics are obtained with a control system in which engine speed is controlled by manipulation of exhaust-nozzle area and turbine-discharge temperature by engine fuel flow. Acceptable although more oscillatory transient responses are obtained with a control system in which speed is controlled by manipulation of engine fuel flow, turbine-discharge temperature is controlled by manipulation of exhaust-nozzle area, and a noninteraction gain term is incorporated in the speed- to the temperature-control loops.

Rocket

FACTORS WHICH INFLUENCE THE SUITABILITY OF LIQUID PROPELLANTS AS ROCKET MOTOR REGENERATIVE COOLANTS. D. R. Bartz. (ARS Spring Meeting, Washington, Apr. 4-6, 1957.) Jet Propulsion, Jan., 1958, pp. 46-53. 39 refs. Brief review of methods of utilizing liquid propellants, and presentation of criteria for acceptable cooling. Methods of analytical and experimental determination of the pertinent heat-transfer characteristics of propellants are described, and the

measured maximum rates at which liquid ammonia can satisfactorily accept heat are presented to show typical trends with variations of fluid pressure, temperature, and velocity. Measured maximum rates for several propellants are compared with predictions of heat fluxes from the combustion gases of these propellants when producing the same thrust in a hypothetical rocket motor, thus obtaining an insight into the importance of various propellant properties and operating conditions.

ROTATING WING AIRCRAFT

PITCH-LAG INSTABILITY OF HELICOPTER ROTORS. Pei-Chi Chou. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 805. 15 pp. Members, $0.50; nonmembers, $0.85. Analysis of the problem of pitch-lag instability in which it is found that even on a rigid whirl tower or with rigid shaft and body support, self-excited oscillations of fully articulated helicopter rotors are possible if the pitch control linkage or the inclination of the lag hinge axis is such that a lag angle increase is accompanied by a pitch angle decrease. A simple physical explanation and a rigorous mathematical analysis are presented. A stability criterion which includes the effects of coupling between pitch-lag and pitch-flap is derived.

PITCH-LAG INSTABILITY AS ENCOUNTERED DURING TESTS OF A MODEL ROTOR. J. W. McKee. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 807. 7 pp. Members, $0.35; nonmembers, $0.75. Experimental investigation of rotor-blade oscillations of a model helicopter rotor. It is suggested that the origin of the oscillations is in the kinematic properties of the blade linkage which cause pitch to be reduced as the blade lags back. Rotor theory for the hovering conditions indicates that such a coupling has a destabilizing influence on lag oscillations. The nature of the oscillations, the test condition effects, the existence of a pitch-lag coupling, the effect of hub modification to remove the coupling, and the effect of lag dampers are described.

SPACE TRAVEL

GRAVITATIONAL TORQUE ON A SATELLITE VEHICLE. R. E. Roberson. Franklin Inst. J., Jan., 1958, pp. 13-22. Determination of the gravitational torque components along the principal axes of inertia for a satellite vehicle in the field of the earth, using a potential function for a small rigid body in the field of an oblate spheroid developed previously by Roberson and Tatistcheff. The defining relationships are not completely reduced for large angular motions of the satellite, but torque components are found explicitly in terms of the angles of attitude deviation from a desired attitude reference for the small-angle case.

ÜBER EINE NÄHERUNGSMETHODE ZUR BERECHNUNG VON KREISBAHNRAKETEN. H. H. Koelle. Raketentech. & Raumfahrtforsch., Jan., 1958, pp. 8-12. In German. Development of an approximate analytical method for the calculation of circular orbits of rocket vehicles. The method permits the determination, with a relatively small time expenditure, of design and performance parameters of a multistage rocket for flight missions which lead from the earth's surface into a circular orbit at arbitrary altitude around the earth. This method also leads to another simplified method for the calculation of long-range rocket vehicles. As an illustrative example the case of a three-stage circular-orbit rocket is treated.

STRUCTURES

THE MATRIX FORCE METHOD OF STRUCTURAL ANALYSIS AND SOME NEW APPLICATIONS. J. H. Argyris and S. Kelsey. Gt. Brit., ARC R&M 3034, 1957. 42 pp. BIS, New York, $2.16. Development of a special method of cut-outs, deriving the structure stresses from the simpler analysis of the corresponding structure without cut-outs under the same loads and/or temperature distribution. A method is also presented for the determination of stresses in a structure, some of whose components are modified subsequent to an initial stress analysis.

Bars & Rods

WPŁYW ZMNIEJSZANIA SIĘ MIMOSRODU NA UGIĘCIA PRĘTÓW MIMOSRODOWO ŚCISKANYCH. Michał Życzkowski. Rozprawy Inżynierskie, No.3, 1957, pp. 399-419. 19 refs. In Polish, with summaries in English and Russian. Analysis of the influence of decreasing eccentricity on the deflections of a bar subjected to eccentric compression, by comparing it with constant eccentricity. Using the exact equation of the deflection curve, the equations are obtained for the maximum deflection in the case of decreasing eccentricity and in the case of constant eccentricity. A four-figure table of the deflections of a bar under buckling is presented.

Beams & Columns

FATIGUE BEHAVIOR OF AIRCRAFT STRUCTURAL BEAMS. Appendix - TYPICAL CALCULATIONS OF MOMENTS OF INERTIA, BUCKLING STRESSES, BENDING MOMENTS, AND DEFLECTIONS. W. S. Hyler, H. G. Popp, D. N. Gideon, S. A. Gordon, and H. J. Grover. US, NACA TN 4137, Jan., 1958. 60 pp. Study of the correlation of composite structural fatigue behavior. Fatigue material, and simple-element behavior. Fatigue and related static tests are made on aluminum-alloy box beams and I-beams, and also on elements simulating key failure locations in the two beams. Results show that for the box beam, the fatigue behavior at the critical location of failure is apparently correlated with the behavior of a simple simulation element. Correlation is obtained when the failure mode and the secondary stresses are duplicated. For the I-beam there appears to be

qualitative agreement with a simulation element. High fatigue notch factors are found in both beams, and the study of simulation elements suggests that such factors may be expected in composite structures where biaxial stress distributions and marked stress gradients occur around rivets.

THE EFFECTS OF INELASTIC ACTION ON THE RESISTANCE TO VARIOUS TYPES OF LOADS OF DUCTILE MEMBERS MADE FROM VARIOUS CLASSES OF METALS. VII - INELASTIC BEHAVIOR OF ALUMINUM ALLOY I-BEAMS WITH ELLIPTIC-TYPE WEB SECTION CUTOUTS. W. J. Worley and F. D. Breuer. USAF WADC TR 56-330, Pt. VII [AD 142217], Dec., 1957. 24 pp. Experimental and theoretical investigation employing the upper bound theorem to predict ultimate loads of various beams. The mathematical relations are developed to enable solution by means of an electronic digital computing machine. The I-beams tested are loaded as simple beams with center loading. The results obtained on the computer indicate that a diamond-shaped web section cutout is the most favorable for resisting fully plastic bending, and the test results substantiate this.

Cylinders & Shells

ON TRANSVERSE VIBRATIONS OF SHALLOW SPHERICAL SHELLS. M. W. Johnson and Eric Reissner. Quart. Appl. Math., Jan., 1958, pp. 367-380. ONR-supported analysis of shallow shells without axial symmetry. Appropriate solutions of the differential equations are obtained and these are used to obtain the frequencies of free vibrations of a spherical shell segment (or cap) with free edges, depending on the curvature of the segment and on the number of nodal circles and diameters.

STABILITY LIMITS FOR A CLAMPED SPHERICAL SHELL SEGMENT UNDER UNIFORM PRESSURE. R. R. Archer. Quart. Appl. Math., Jan., 1958, pp. 355-366. 16 refs. Development of an integration procedure for differential equations of finite deflections in clamped shallow spherical shells. Stability limits for the clamped shell are obtained for a range of central height to thickness ratios from about 1 to 35. It is noted that problems of finite axisymmetric deflections of flat plates are included as a limiting case of the shallow shell, and the methods presented carry over to such a problem.

EDGE STRESSES IN THIN SHELLS OF REVOLUTION. W. H. Wittrick. Australian J. Appl. Sci., Dec., 1957, pp. 235-260. Presentation of explicit solutions for stress systems which decay rapidly with the distance from either a circular or a meridional edge of a thin shell whose shape is a surface of revolution but otherwise arbitrary. The accuracy of the solutions is consistent with that of the generally accepted equations of thin shell theory. The significance of these solutions from the point of view of the boundary conditions of membrane theory is discussed.

Elasticity & Plasticity

THERMO-ELASTIC SIMILARITY LAWS. A. E. Green, J. R. M. Radok, and R. S. Rivlin. Quart. Appl. Math., Jan., 1958, pp. 381-393. Determination of conditions which must be satisfied by the physical parameters describing the properties of a body and a scale model, in order that the stress in the original body may be determined from that at the corresponding position and time in the scale model by means of the multiplier M (rigidity modulus of body/rigidity modulus of model).

CIŚNIENIE ZREDUKOWANE JAKO JEDEN Z PARAMETRÓW WYTĘŻENIA (PRZYROST WŁAŚCIWEJ ENERGII SWOBODNEJ JAKO MIARA WITEŻENIA). Jerzy Zawadzki. Rozprawy Inżynierskie, No. 3, 1957, pp. 357-398. 80 refs. In Polish, with summaries in English and Russian. Analysis of reduced pressure as a strength parameter and the increase of unit free energy as a measure of effective stress. A strength theory applicable in practise is developed, based on the fundamental assumptions and laws of the theory of solid bodies. It can also be applied to many materials, a number of technically important metals, and after some improvements, taking into account entropy changes, to plastics.

Plates

A CLOSED SOLUTION IN THE CASE OF A SEMI-INFINITE PLATE WITH DISCONTINUOUS BOUNDARY CONDITIONS. Artur Kacner. Arch. Mech. Stosowanej, No. 4, 1957, pp. 371-380. Investigation of the problems of statics and dynamics of plates, and derivation of a solution by means of Fredholm's integral equation of the second kind. This solution, when passing to the limit with the value ω of the Winklerian coefficient of support of a boundary segment, becomes Fredholm's equation of the first kind. The discussion of the solution confirms the results obtained in a previous investigation and enables a conclusion to be made concerning the boundary force behavior when the Winklerian coefficient ω of the boundary segment decreases to zero. It is shown that in this case the function of boundary force is identical with the function for the case of homogeneous boundary conditions at points separating neighboring segments of different support conditions.

BUCKLING OF SIMPLY SUPPORTED PLATES UNDER ARBITRARY SYMMETRICAL TEMPERATURE DISTRIBUTIONS. J. M. Klosner and M. J. Forray. J. Aero. Sci., Mar., 1958, pp. 181-184. Plane-stress solution for a plate subjected to an arbitrary symmetric temperature distribution, assuming straight plate edges. The deflection function for the buckled plate is approximated by the first four terms of a double infinite harmonic

series, and the Rayleigh-Ritz procedure is used to determine approximately when initial buckling occurs.

A PLANE DISTORTION PROBLEM. Witold Nowacki. Arch. Mech. Stosowanej, No. 4, 1957, pp. 417-438. Theoretical investigation of a simply connected thin plate free from stresses at the edges, assuming a given strain state in the region Γ of the plate and zero strain components outside that region. The strain and stress components are determined for given initial deformations, using Green functions for generalized displacement equations and the generalized Airy equation. The method is illustrated by means of three examples: an infinite plate, a semi-infinite plate, and a plate strip.

ELASTIC-PLASTIC BENDING OF NON-HOMOGENEOUS ORTHOTROPIC CIRCULAR PLATES. W. Olszak and J. Murzewski. Arch. Mech. Stosowanej, No. 4, 1957, pp. 467-485. 23 refs. Investigation of plates of variable thickness assuming an axially symmetric distributed load and a cylindrically orthotropic material characterized by a continuous nonhomogeneity of such type that the elastic and plastic moduli are functions of the distance from the plate center only. It is further assumed that the plate thickness is small as compared with its radius and the deflection is small in respect to the plate thickness. The principal assumptions are based on results obtained by Olszak and Urbanowski for nonhomogeneous anisotropic bodies.

EINFLUSS EINER UNENDLICHEN REIHE GLEICHER KREISLÖCHER AUF DIE DURCHBIEGUNG EINER DÜNNEN PLATTE. O. Tamate. ZAMM, Nov.-Dec., 1957, pp. 431-441. 10 refs. In German. Application of the Kirchhoff theory of bending and the complex representation due to Muskhelishvili to obtain an estimate of the influence which an infinite series of equal circular holes will have on the stress distribution in a plate subjected to bending moments. A perturbation theory is used to determine the coefficients included in the deflection function.

BEITRÄGE ZUR DIAZ-GREENBERG-METHODE. Rüdiger Nicolovius. ZAMM, Nov.-Dec., 1957, pp. 449-457. 10 refs. In German. Application of the Diaz-Greenberg method to boundary value problems of a more general character by means of the hypercircle method due to Synge. The proof is given for fourth-order boundary value problems, and the method is illustrated by a numerical example and compared with the Maple-Synge method. Includes discussion of some further applications of the method.

Sandwich Structures

THERMAL STRESSES AND DEFLECTIONS IN RECTANGULAR SANDWICH PLATES. P. P. Bijlaard. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 777. 15 pp. Members, $0.50; nonmembers, $0.85. Derivation of equations for bending moments, torsional moments, and transverse shear forces, assuming the temperature of the upper surface higher than that of the lower one, and specially considering the required edge reactions. It is shown that, except for cases where all edges are clamped or all edges are simply supported, transverse shear forces occur, so that the shear deformation of the core has to be considered. Plates with two opposite edges simply supported and the other two free or clamped are dealt with, and the case where three edges are simply supported and the fourth edge is free is computed. Graphs of some numerical results are presented.

Thermal Stress

THERMAL DISPLACEMENTS IN AN ELASTIC SEMI-SPACE DUE TO SUDDEN HEATING OF THE BOUNDARY PLANE. Jozef Ignaczak. Arch. Mech. Stosowanej, No. 4, 1957, pp. 395-416. Mathematical investigation leading to a solution of the equations of motion of the theory of thermoelasticity in a semi-space for given boundary and initial conditions. The methods used are based on the elementary properties of operational calculus, in particular on the Fourier integral transformation and a number of properties of the Dirac function. Certain properties of retarded potentials are also used, as well as the tensor notation in writing the equations. The problem is divided into three parts: derivation of the equations, consideration of the temperature distribution, and solution of the principal problem.

PODSTAWY TEORII PEŁZANIA USTROJÓW HIPERSTATYCZNYCH WSTĘPNIE SPRĘŻONYCH. Czesław Eimer. Rozprawy Inżynierskie, No. 3, 1957, pp. 421-458. 19 refs. In Polish, with summaries in English and Russian. Investigation, based on the Volterra-Boltzmann general linear-creep theory, of the foundations of the theory of creep in statically indeterminate prestressed structures, and derivation of equations for determining the redundant quantities as functions of time. A general discussion for solving such equations is included, and consideration is given to the following principal ways in which the theory can be simplified: simplification of the equations of internal statical indeterminacy, simplification of the equations of external statical indeterminacy, and replacement of integral equations by differential equations.

THERMODYNAMICS

Heat Transfer

SOME HEAT CONDUCTION SOLUTIONS INVOLVED IN TRANSIENT HEAT TRANSFER MEASUREMENTS. R. J. Cresci and P. A. Libby. USAF WADC TN 57-236 [AD 130800], Sept., 1957.

27 pp. Development of a transient measurement technique allowing tests to be run at variable Reynolds Numbers, and using a cylindrical plug for transforming the general three-dimensional temperature distribution within the body into a local distribution, due to the one-dimensional heat flow in the plug. The analyses used in the determination of local heat transfer rates are obtained by solving the one-dimensional heat conduction equation with a variety of boundary conditions which are subdivided into two major classifications: (a) simpler solutions obtained for low heat transfer rates and short heating times, and (b) more complex solutions used when the model is subjected to high rates of heat transfer over relatively long period of time. Solutions for constant heat transfer coefficient, constant heat rate, and arbitrary surface temperature are obtained, and the standard heat conduction solutions are adapted to particular heat-transfer-measurement conditions.

THE DETERMINATION OF ABSOLUTE INTENSITIES AND F-NUMBERS FROM SHOCK-TUBE STUDIES. S. S. Penner. CIT Jet Propulsion Lab. TR 5, Dec., 1957. 42 pp. 71 refs. USAF-supported discussion of the basic physical laws refering to equilibrium radiation from heated gases, and a critical evaluation of experimental procedures for absolute intensity measurements which also apply to shock tube studies. A summary is given on published experimental shock-tube studies of emissivity measurements for air, along with qualitative spectroscopic studies behind shock fronts for selected atomic and molecular systems. The quantitative interpretation of two-path data for the determination of temperature, concentration, and absolute intensities is explained.

VTOL & STOL

PRELIMINARY INVESTIGATION OF A DUCTED FAN IN LIFTING FORWARD FLIGHT. N. D. Ham and H. H. Moser. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 827. 19 pp. 11 refs. Members, $0.50; nonmembers, $0.85. Wind-tunnel measurements of lift, drag, pitching moment, and rotor power in the chord-plane of a wing section, and preliminary wave survey of the rotor inflow corresponding to various flight conditions. The results are presented in graphical form. A tuft study of the flow over the wing is made, and a qualitative discussion of the results of this study is included. Analytic comparisions of the above results with existing theories are presented together with a discussion of the results of the program.

THE FLYING PLATFORM AS A RESEARCH VEHICLE FOR DUCTED PROPELLERS. A. H. Sacks. IAS 26th Annual Meeting, New York, Jan. 27-30, 1958, Preprint 832. 15 pp. Members, $0.50; nonmembers, $0.85. Army-Navy-sponsored discussion of some of the aerodynamic and dynamic problems peculiar to the ducted propeller. The tilt angles required for forward flight equilibrium are calculated by momentum theory, and a new theory is developed for the pitching moments on a ducted propeller in forward flight. Theoretical predictions are compared with data obtained from wind tunnel tests and full-scale truck tests, and the results are discussed. The dynamic stability of the flying platform is also considered, and the stability in hovering is calculated with and without automatic stabilization.

EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF SOME SHROUD DESIGN VARIABLES ON THE STATIC THRUST CHARACTERISTICS OF A SMALL-SCALE SHROUDED PROPELLER SUBMERGED IN A WING. R. T. Taylor. US, NACA TN 4126, Jan., 1958. 23 pp. Study to determine the effects of shroud-lip radius of curvature, shroud length, and shroud diffuser angle on the static thrust characteristics. Also included are the effects of the distance from the shroud exit to the ground on the distance available for take-off. The data indicate that when a shroud-lip radius of curvature below 6% of the propeller diameter is used, marked reductions in static thrust efficiency result. Relatively minor losses in static thrust efficiency occur as a result of decreasing the shroud length. Increases in exit area result in some minor losses in static thrust efficiency. Close proximity of the shroud exit to the ground can result in very large losses in thrust.

EXPERIMENTAL INVESTIGATION OF THE LATERAL TRIM OF A WING-PROPELLER COMBINATION AT ANGLES OF ATTACK UP TO 90° WITH ALL PROPELLERS TURNING IN THE SAME DIRECTION. W. A. Newsom, Jr. US, NACA TN 4190, Jan., 1958. 27 pp. Experimental investigation using a model with four propellers, the slipstream from which covered practically the entire span of the wing. Tests are made at angles of attack up to 90° for various differential flap deflections and differential blade pitch on the outboard propellers. The lateral trim of the configuration tested is marginal and it seems likeley, therefore, that some tilting-wing VTO aircraft could be trimmed with all the propellers rotating in the same direction whereas others could not.

WATER-BORNE AIRCRAFT

DVIZHENIE PLASTINKI BESKONECHNOGO RAZMAKHA VBLIZI SVOBODNOI POVERKHNOSTI IDEAL'NOI NEVESOMOI ZHIDKOSTI. E. A. Fedorov. AN SSSR Dokl., Sept. 21, 1957, pp. 373-376. In Russian. Derivation of a solution for the problem of motion of a plate of infinite span near the free surface of an ideal imponderable liquid. The types of flow considered in the problem are those by which the upper surface of the plate is partly or entirely washed by the liquid. Also considered are the limiting cases where the separation of free streams occurs directly at the leading edge of the plate.

A METHOD FOR CALCULATION OF HYDRODYNAMIC LIFT FOR SUBMERGED AND PLANING RECTANGULAR LIFTING SURFACES. K. L.

Wadlin and K. W. Christopher. US, NACA TN 4168, Jan., 1958. 34 pp. 13 refs. Development of a method for surfaces of aspect ratios from 0.125 to 10 operating at finite depths beneath the water surface, including the zero depth or planing condition. Theoretical values are compared with experimental values obtained at various depths of submergence with lifting surfaces of aspect ratios from 0.125 to 10. The method can also be applied to hydrofoils with dihedral. Lift coefficients computed by this method are in good agreement with existing experimental data for aspect ratios from 0.125 to 10 and dihedral angles up to 30°.

KOSOI UDAR O ZHIDKOST'. I. T. Egorov. AN SSSR Otd. Tekh. Nauk Izv., Aug., 1957, pp. 41-47. In Russian. Investigation of the impact of a flat plate of infinite span on the surface of a liquid, assuming that at the time of the impact the plate has a relative-velocity vector component parallel to the undisturbed surface of the liquid. The interaction process is divided into two phases -- (a) the plate penetrating water and (b) the subsequent unsteady motion of the plate with a constant or, in the case of high horizontal speeds, the varying wetted length.

WIND TUNNELS & RESEARCH FACILITIES

DESIGN AND OPERATION OF HUPERSONIC WIND TUNNELS. R. Smelt and J. C. Sivells. (NATO AGARD 11th Wind Tunnel & Model Testing Panel, Scheveningen, July 8-12, 1957.) NATO AGARD Rep. 135, July, 1957. 37 pp. 72 refs. Discussion of air-supply, diffuser efficiency, heater design and operation, nozzle design and calibration, as well as instrumentation problems. Real (imperfect) gas effects and the application of hypersonic-wind-tunnel results to flight problems are also investigated, and solutions are given, based on experience of the design and operation of the Gas Dynamics Facility at the Arnold Engineering Development Center.

SHOCK TUBE DRIVER TECHNIQUES AND ATTENUATION MEASUREMENTS. Ch. E. Wittliff and M. R. Wilson. Cornell Aero. Lab. Rep. AD-1052-A-4 (AFOSR TN 57-546) [AD 136531], Aug., 1957. 34 pp. 10 refs. Study of the techniques and different driver gases for producing shock waves (M>4) and the resultant attenuation of the shock waves in the low pressure tube. It is shown that the amount of attenuation increases with increasing shock wave strength, and the more efficient a given driver technique is in producing the shock wave, the larger is the attenuation degree. Presently available theories on shock wave attenuation are reviewed, and it is concluded that the theories do not accurately predict the attenuation of shock waves having Mach Numbers greater than 2.

EXPERIMENTAL AND THEORETICAL STUDY OF MEAN BOUNDARY CONDITIONS AT PERFORATED AND LONGITUDINALLY SLOTTED WIND TUNNEL WALLS. C. F. Chen and J. W. Mears. USAF AEDC TR 57-20 [AD 144320], Dec., 1957. 42 pp. Derivation of a mean boundary condition for the flow of an incompressible inviscid fluid along a longitudinally slotted wall, taking into account the finite thickness of the slots. The flow is investigated near a wall along its longitudinal axis, and the results show that the mean boundary condition is satisfied in the middle portion of the region. The mean boundary condition derived by Maeder and Wood for a perforated wall is investigated. Results show that the mean boundary condition is not satisfied at either end of the test section. On the middle portion the mean boundary condition would be satisfied if it were modified by an additional constant.

A SIMPLE METHOD OF IMPROVING THE SUPERSONIC VELOCITY DISTRIBUTION IN A TRANSONIC TUNNEL HAVING SLOTTED WALLS. C. N. Hall. Gt. Brit., RAE TN Aero. 2517, July, 1957. 13 pp. Description of the modification of the centerline distribution of Mach Number at supersonic speeds by means of curved lengths of perforated steel plate set behind a proportion of the suction slots in the walls of the working section. It is found that the slope and curvature of the perforated strips and the distance from the suction slots determine the effect of the plates on the distribution of Mach Number. A form of plate is evolved which reduces the variation of Mach Number about the mean from ±0.010 to ±0.006 at the maximum Mach Number.

USE OF A FREE MOLECULE PROBE IN HIGH SPEED RAREFIED GAS FLOW STUDIES. Appendix - CORRECTION FOR END CONDUCTION. J. A. Laurmann and D. C. Ipsen. USAF WADC TR 57-440 [AD 142109], Oct., 1957. 40 pp. 12 refs. Investigation of two flow configurations, namely, the leading edge regions of a wedge and a flat plate at zero angle of attack, both at nominal Mach Numbers of 4 to 6. Results show the nature of the flow, and the shock wave position; the boundary layer is easily discernible from the changes in temperature and heat transfer coefficient of the wire.

PRESENTATION D'UNE MAQUETTE DE RECHERCHE EN VOL HORIZONTAL RECTILIGNE DANS LE DOMAINE DES VITESSES TRANSSONIQUES. Paul Lygrisse and André Rémondière. La Recherche Aéronautique, Nov.-Dec., 1957, pp. 13-17. In French. Development of an experimental method and application to a model in rectilinear horizontal flight in the transonic range, in order to put this model into a fixed trajectory before the guidance becomes effective. This method is based on the observation and control of certain movements of the center of gravity and around the center of gravity of the model. Includes description of the model and of the equipment used and presentation of experimental results.

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Antennas

The Electroforming Process Used in the Fabrication of a Broadband Single Ridged Antenna Horn. Joseph Schramp. *USAF RADC TR 57-155 [AD 131262]*, Oct., 1957. 7 pp. Description of a process which proved the most suitable in meeting the design requirements of the horn.

Pattern of a Flush-Mounted Microwave Antenna. James R. Wait. *J. Res.*, Oct., 1957, pp. 253–259. 13 refs. Application of a harmonic series representation to the analysis of the far zone radiation from an axial slot on a circular cylinder of infinite length.

Integral Equation for Currents in the Theory of Metal Antennas. A. V. Gaponov and M. A. Miller. *Sov. Phys. - Tech. Phys.*, Oct., 1957, pp. 2,674–2,678. 11 refs. Discussion concerning the error in the use of the integral equation method in antenna theories when the field created by magnetic currents is neglected.

Radiation from Slots on Dielectric-Clad and Corrugated Cylinders. James R. Wait and Alyce M. Conda. *J. Res.*, Nov., 1957, pp. 307–316. Derivation of an approximate formula for the radiation pattern of an axially slotted cylinder with a thin dielectric coating. Using a similar method, the pattern function for a slot on a corrugated cylinder is derived.

An Experimental Wide Band Parabolic Aerial for the 2,000 Mc/s Band. N. Ganapathy and P. E. G. T. Hopkins. *Marconi Rev.*, 4th Quarter, 1957, pp. 134–152. Description of a 10-ft. diameter parabolic dish aerial suitable for 30 per cent bandwidth at 2,000 mc./sec., and discussion of design considerations for the primary feed and the associated waveguide feeder.

Rhombic Aerials; Design Charts for High Frequencies. F. J. Norman and J. F. Ward. *Electronic & Radio Engr.*, Nov., 1957, pp. 398–403. 11 refs. Derivation of a method whereby a set of charts of open scale give the aerial parameters for high-frequency operation. The angle of fire and the gain with respect to a dipole in free space are displayed for an adequate range of aerial side lengths and included angles.

Circuits & Components

Stacked Valve Circuits. J. B. Earnshaw. *Electronic & Radio Engr.*, Nov., 1957, pp. 404–406. Analysis of a circuit common to all stacked valve (tube) arrangements, and the results for specific circuits appear as simplifications of the general equations. The stacked valve circuits are defined as arrangements where the valves are connected in series across a common d.c. supply.

Control Circuit Design. N. B. Acred. *Electronic Eng.*, Dec., 1957, pp. 586–590. Description of a diagram method for the simplification of Boolean algebraic expressions. The control circuit design is simplified by the introduction of the time sequence concept.

Design of Capacitive Divider Coupling Circuits. Irving Dlugatch. *Electronic Des.*, Dec. 15, 1957, pp. 20, 21. Description of a streamlined technique for designing capacity-coupled rf stages.

Solving Missile Relay Problems. Marvin E. Thomson. *Mil. Electronics*, Nov., 1957, pp. 26–28. Development of improved methods for evaluating relays to be used under extreme environmental conditions.

Miniaturizing Magnetometers. Martin E. Packard. *Mil. Electronics*, Nov., 1957, pp. 22–24. Development of equipment for measuring the earth's magnetic field, small enough to be carried in satellite vehicles.

The Frequency-Lock A.F.C. Circuit as a Means of Tracking Signals of Changing Frequency in Conditions of Low Signal/Noise Ratio. R. Leek. *(IEE Paper 2411 R.) IEE Proc., Pt. B*, Nov., 1957, pp. 587–597. 12 refs. Qualitative discussion of the noise-free operation of the loops, followed by a theoretical analysis. Practical results are in agreement with the theory.

Transistor Circuits and Applications. A. G. Milnes. *(IEE Paper 2368 R.) IEE Proc., Pt. B*, Nov., 1957, pp. 565–580. 112 refs. Discussion of new concepts and trends in design, and description of improvements in transistor ratings.

Dual-Purpose Circuitry Cuts Transceiver Size. Paul G. Wulfsberg and Charles H. Kirkpatrick. *Electronics*, Dec. 1, 1957, pp. 134–138. Description of a 1,750-channel transceiver using 35 crystals and 28 tubes for ground-to-air communications (225-400 mc.), which may be installed in fixed or mobile stations. Transmitter delivery amounts to 15 watts, and receiver sensitivity is better than 5 μv.

Estimation Methods in the Theory of Non-Linear and Time-Variable Filters. R. Kulikowski. *Acad. Pol. Sci. Bul.*, No. 4, 1957, pp. 243–251. Method which allows the determination of the limits within which the solution is contained, without the necessity of solving the set of equations describing the properties of the filters.

Unique Relay for Airborne Systems. Rudolf Steiner. *Mil. Electronics*, Dec., 1957, pp. 40, 41. Design of a relay based on the simultaneously and jointly acting repulsion and attraction between cores of ferrous material, arranged appropriately within an electromagnetic field.

Uniform Realisation of Operators by Means of Linear Elements. R. Kulikowski. *Acad. Pol. Sci. Bul.*, No. 4, 1957, pp. 253–260. Development of operators for telecommunication equipment, electronic computers, etc., including the synthesis of transmission systems and of the "integrating" circuits.

High Power Microwave Filters. Joseph H. Vogelman. *USAF RADC TR 57-148 [AD 131248]*, Oct., 1957. 63 pp. Description of two design procedures and analysis of physical performance. Includes consideration of radar-to-communication-interference problems.

Communications

Some Remarks on Statistical Methods in Communication Theory. J. Seidler. *Acad. Pol. Sci. Bul.*, No. 4, 1957, pp. 261–267. Mathematical investigation of the receiver function including some well-known definitions.

Constant Amplitude Speech. P. J. Ferrell. *USAF RADC TN 57-317 [AD 131270]*, Oct., 1957. 16 pp. 13 refs. Description of a constant amplitude speech generator, and presentation of test results which indicate that constant amplitude speech is an excellent method of increasing voice intelligibility.

The Canadian JANET System. G. W. L. Davis, S. J. Gladys, G. R. Lang, L. M. Luke, and M. K. Taylor. *IRE Proc.*, Dec., 1957, pp. 1,666–1,678.

Bandwidth Considerations in a JANET System. L. L. Campbell and C. O. Hines. *IRE Proc.*, Dec., 1957, pp. 1,658–1,660.

The Principles of JANET—A Meteor-Burst Communication System. P. A. Forsyth, E. L. Vogan, D. R. Hansen, and C. O. Hines. *IRE Proc.*, Dec., 1957, pp. 1, 642–1,657. 42 refs. Survey of the propagation characteristics and design considerations of the JANET system—a long range communication system employing V.H.F. radio signals which are forward-scattered by the ionized trails of individual meteors.

Storage Capacity in Burst-Type Communication Systems. L. Lorne Campbell. *IRE Proc.*, Dec., 1957, pp. 1,661–1,666. Derivation of the relationship between storage capacity and mean rate of transfer of information for a JANET type system.

An Investigation of Storage Capacity Required for a Meteor-Burst Communications System. Robert A. Rach. *IRE Proc.*, Dec., 1957, pp. 1,707–1,709. USAF-sponsored study of two main categories of storage devices which correspond to the magnetic tape and magnetic core type units currently in use on burst circuits.

On the Wavelength Dependence of the Information Capacity of Meteor-Burst Propagation. Von R. Eshleman. *IRE Proc.*, Dec., 1957, pp. 1,710–1,714. USAF-supported research.

Directional Characteristics of Meteor Propagation Derived from Radar Measurements. V. R. Eshleman and R. F. Mlodnosky. *IRE Proc.*, Dec., 1957, pp. 1,715–1,723. 18 refs. USAF-supported investigation presenting the preliminary results of radar measurements applied to an east-west and a north-south meteor propagation path.

On the Influence of Meteor-Radiant Distributions in Meteor-Scatter Communication. M. L. Meeks and J. C. James. *IRE Proc.*, Dec., 1957, pp. 1,724–1,733. 13 refs. USAF-Navy-supported study of the relative effectiveness of various regions of the atmosphere in furnishing usable meteor trails made on the basis of several distributions of meteor radiants.

A Meteor-Burst System for Extended Range VHF Communications. W. R. Vincent, R. T. Wolfram, B. M. Sifford, W. E. Jaye, and A. M. Peterson. *IRE Proc.*, Dec., 1957, pp. 1,693–1,700. USAF-sponsored development of a low-power burst communication system utilizing the intermittent propagation path provided by ionized meteor trials. Details of the burst control techniques and storage devices used to handle the intermittent information flow are discussed along with the overall system design.

Analysis of Oblique Path Meteor-Propagation Data from the Communication Viewpoint. W. R. Vincent, R. T. Wolfram, B. M. Sifford, W. E. Jaye, and A. M. Peterson. *IRE Proc.*, Dec., 1957, pp. 1,701–1,707. USAF-sponsored study.

Quadruple-Diversity Tropospheric Scatter Systems. William G. Long and R. Ray Weeks. *IRE Trans., CS Ser.*, Dec., 1957, pp. 8–19. 12 refs. Discussion of a system employing tropospheric scattered fields to achieve highly reliable circuits at distances well beyond radio line-of-sight.

Intermittent Communications with a Fluctuating Signal. G. Franklin Montgomery. *IRE Proc.*, Dec., 1957, pp. 1,678–1,684. USAF-supported discussion of intermittent transmission as a method to control the effects of signal fading. The method is evaluated for Rayleigh-fading signals, using binary frequency modulation and phase modulation.

The Utility of Meteor Bursts for Intermittent Radio Communication. G. F. Montgomery and G. R. Sugar. *IRE Proc.*, Dec., 1957, pp. 1,684–1,693. USAF-supported analysis of meteor bursts measured on the 49.8-mc. transmissions implies that useful intermittent communication can be achieved.

Construction Techniques

Special Issue: Planning for Low-Cost Production. *Electronic Des.*, Nov. 15, 1957, pp. 30–111. *Partial Contents:* Prototype Design Compatible with Production. Save Costs in Drafting. Standardization. Selecting Materials and Components for Low-Cost Production. Labor Savings with Printed Wiring. Sheet Metal Design. Costs-Savings with Plastics. Packaging for Economy. Process Evaluation and Value Analysis. Hand Assembly vs. Automatic Production. Designs for Low-Cost Production.

The Economics of Component Parts Selection. E. F. Fuegel. *Elec. Eng.*, Nov., 1957, pp. 958–962. Discussion of engineering costs, rating of component parts, customer losses, in addition to a formula for determining the cost of a part.

Effect of Elastic Racks on Vibration Mounting of Equipment. R. A. Di Taranto. *J. Appl. Mech.*, Dec., 1957, pp. 617–620. Analysis considering a simply supported uniform beam with a uniform mass distribution representing the electronic equipment, mounted on two equal springs. Rayleigh type solution method is used.

Connecting Components for Telecommunications Equipment. A. Corriez. *(Onde Elec.*, 1955, pp. 413–416.) *Gt. Brit., MOS TIL/T4669*, Sept., 1957. 6 pp. Consideration of the problem of linking up various components or assemblies.

Electronic Reliability. G. G. Brown and R. J. Dennis. *Missiles & Rockets*, Oct., 1957, pp. 172–176. Discussion of the application of failure-rate curves and parameter-drift curves to the design, use of component screening, and "trade-off" techniques.

Cooling

Use of the Heat Exchanger in Cooling Airborne Electronic Equipment. Allan D. Kraus. *Sperry Eng. Rev.*, Sept.-Oct., 1957, pp. 11–16. Description of an air-to-air convective heat exchanger which regulates and controls the temperature both within and exterior to a package containing airborne electronic equipment.

Delay Lines

Synthesis of Lumped Parameter Precision Delay Line. E. S. Kuh. *IRE Proc.*, Dec., 1957, pp. 1,632–1,642. Presentation of a design technique for precision time domain applications. The network obtained is a tandem connection of a low-pass ladder which provides the shape of time response and an all-pass bridge structure which gives the desired time delay.

Dielectrics

Research Progress in Dielectrics—1957. Alex E. Javitz. *Elec. Mfg.*, Dec., 1957, pp. 94–103, 326. Review of new materials and their properties, and discussion of the research on the mechanism of electrical breakdown, as well as the physical and chemical degradation of materials.

Electronic Tubes

Techniques for Application of Electron Tubes in Military Equipment. Rex S. Whitlock. *(USAF WADC TR 55-1*, Oct., 1955.) *USAF WADC TR 55-1 [AD 142061]*, Oct., 1957. 513 pp. Discussion includes tube properties grouped according to ratings and circuit operation, tube properties in relation to circuit design, numerical data, and product distribution curves.

Metal Ceramic Tubes to Withstand 500 C and High Vibration. John H. Wyman and R. H. Kuhnapfel. *Electronic Des.*, Dec. 15, 1957, pp. 24–27. Description of an approach to the problems encountered beyond the convecting gases of the earth's atmosphere. The glass envelope of a conventional tube is replaced with a metal ceramic envelope, using the envelope as the anode, and providing a suitable getter to replace the barium flash getter.

Understanding the New Microwave Tubes. I—The Traveling Wave Amplifier. *Aeronox Res. Worker*, Aug.-Sept., 1957. 5 pp. Discussion of the physical principles of a traveling wave amplifier.

Selection and Application of Travelling Wave Tubes. II. N. Hansen and A. Nielsen. *Electronic Des.*, Dec. 1, 1957, pp. 36–39. Discussion of the design of associated solenoids and power supplies, and procedures for selecting the proper TWT operating performance.

Measurement & Testing

An Apparatus for Measuring the Piezoresistivity of Semiconductors. R. F. Potter and W. J. McKean. *J. Res.*, Dec., 1957, pp. 427–430.

Oscillators & Signal Generators

LC-Oscillator Parameters and Frequency Stability. J. Groszkowski. *Acad. Pol. Sci. Bul.*,

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No. 4, 1957, pp. 235–242. The investigation is carried out to define the frequency stability in relation to nonlinear factors for an oscillator with a negative resistance having a simple cubic characteristic, and for working conditions not far from the regeneration threshold.

Radar

MTI Uses Two-Persistence CRT. A. S. Luftman. *Mil. Electronics*, Dec., 1957, pp. 25, 26. Discussion of a radar-history remote indicator that uses a storage tube memory to record all targets appearing on the radar and also target trails indicating the previous history of their actions.

Semiconductors

Metal Rectifiers and Semi-Conductors. *The Engr.*, Oct. 18, 1957, pp. 570–572. Discussion of the use of copper-oxide, selenium, germanium, and silicon as rectifiers.

The Elemental Semiconductors—Silicon and Germanium. II, III. J. Shields. *Elec. Energy*, Nov., Dec., 1957, pp. 477–482; 501–503. Discussion on the preparation and purity of crystals, and application of pn junctions to rectifiers and transistors.

Thermal Turnover in Germanium P-N Junctions. A. W. Matz. *(IEE Paper 2431 R.) IEE Proc., Pt. B*, Nov., 1957, pp. 555–564. 32 refs. Experimental verification and semi-quantitative analysis, showing fairly good agreement with the theory.

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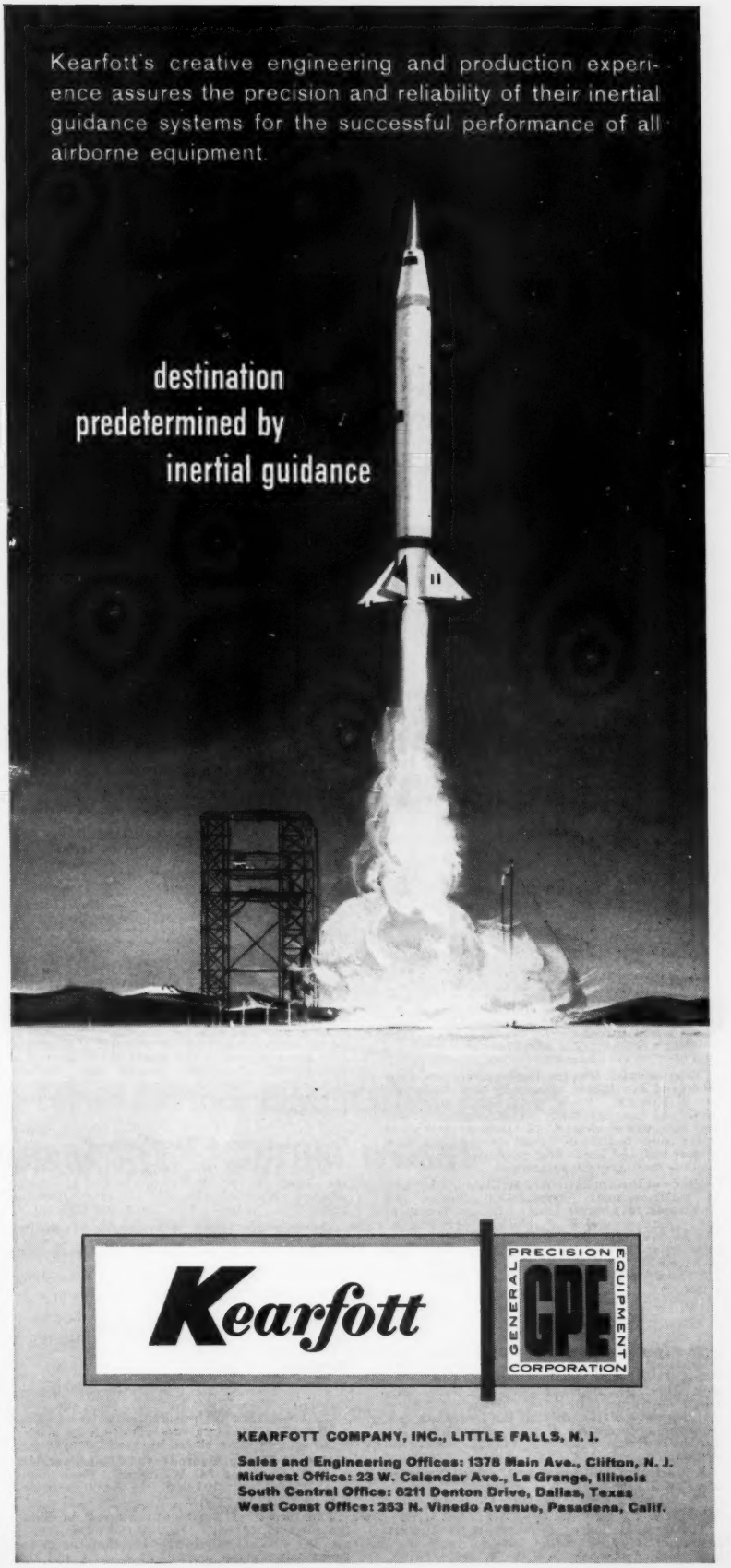
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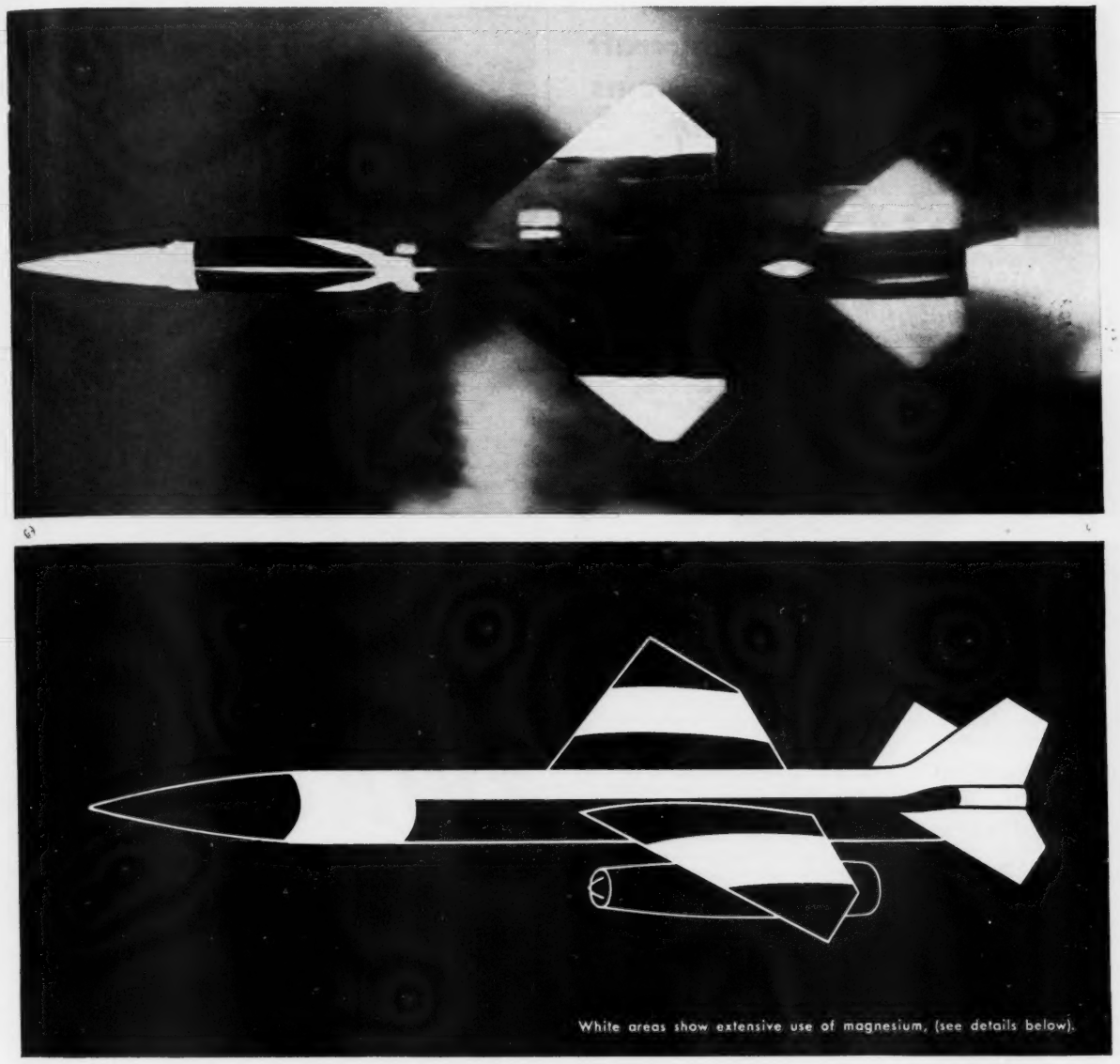

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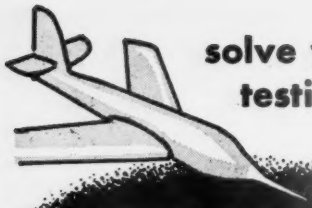

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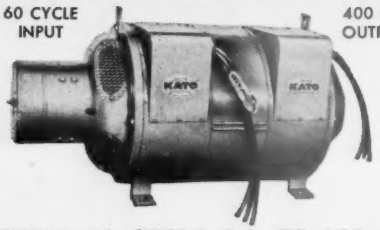

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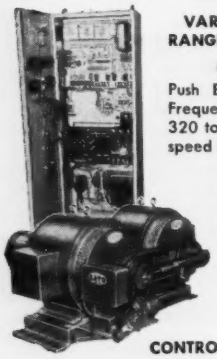

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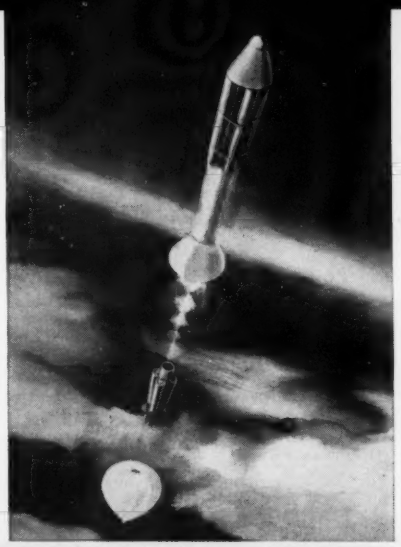

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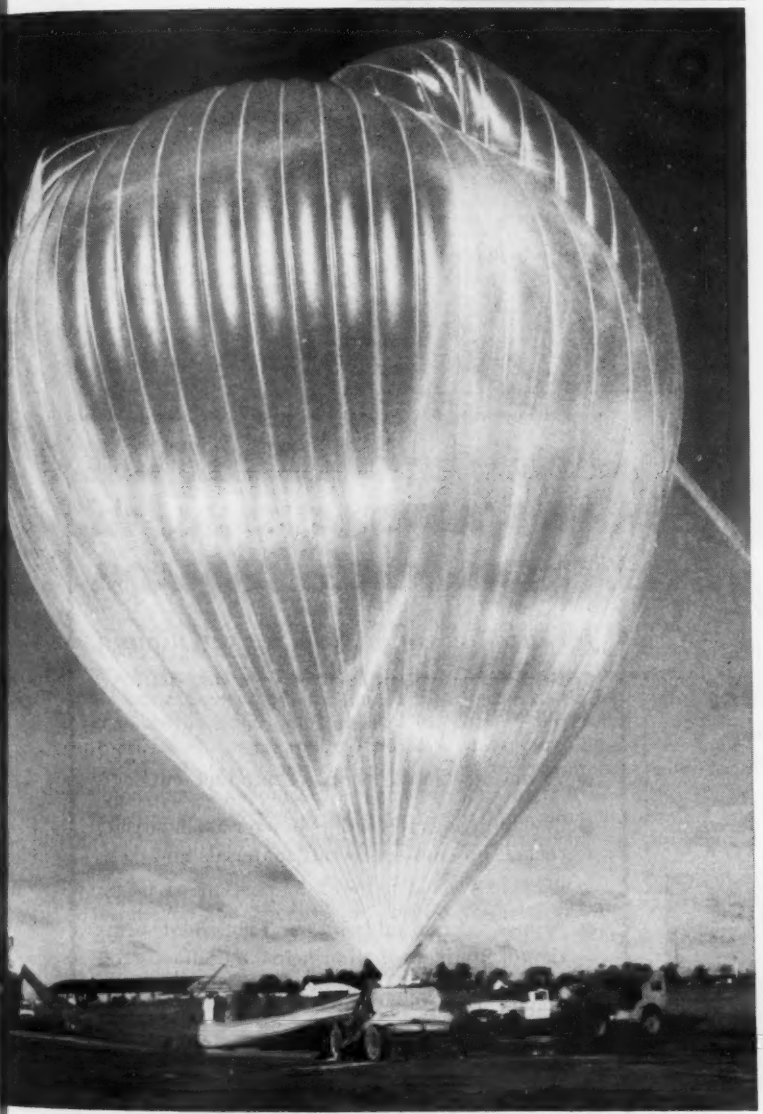

This Project Farside polyethylene balloon is identical to the one used in the actual rocket flights. Here it is being readied for a test ascent. Its load is an exact replica (size and weight) of the platform and rockets which were carried to 100,000 feet at Eniwetok Atoll.

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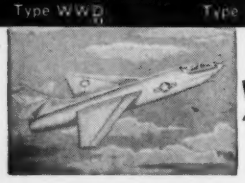

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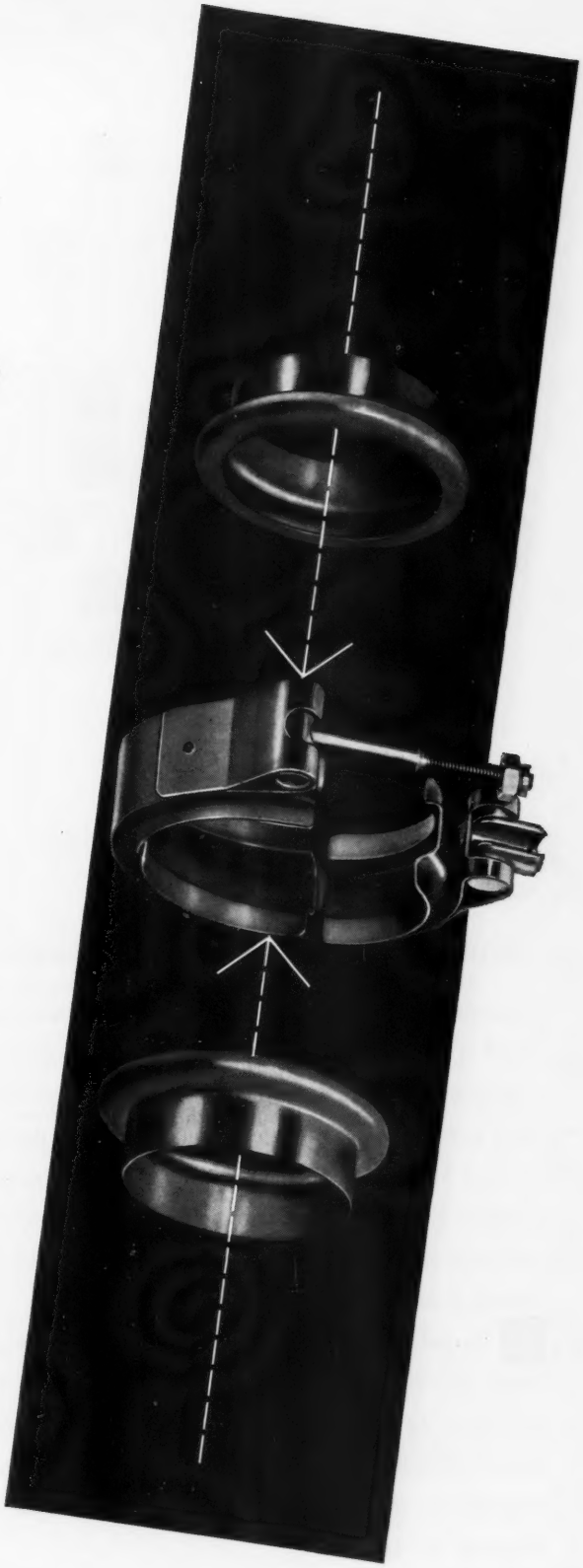

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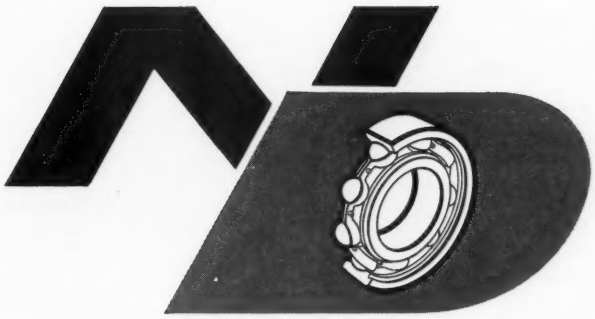

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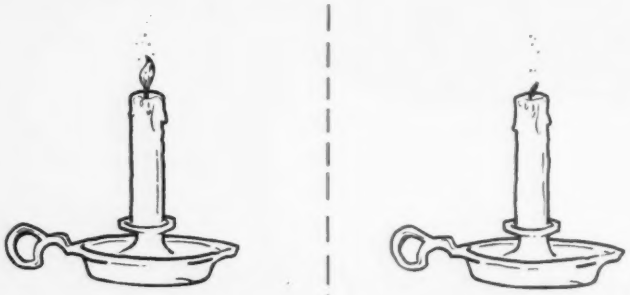

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A Donnell Type Theory for Asymmetrical Bending and Buckling of Thin Conical Shells. Paul Seide. (*ASME Summer Conference, Berkeley, Calif., June 13–15, 1957, Paper 57—APM-42.*) *J. Appl. Mech.*, Dec., 1957, pp. 547–552. Presentation of equations that reduce to Donnell's equations for thin cylindrical shells when the cone semivertex angle becomes very small and the minimum radius of curvature of the median surface approaches a constant value.

On Vibrations of Conical Shells. G. Herrmann and I. Mirsky. (*Columbia U. Inst. Flight Struc. TN 4*, Apr., 1957.) *IAS 26th Annual Meeting, New York, Jan. 27–30, 1958, Preprint 766.* 15 pp. Members, $0.50; nonmembers, $0.85.

Stability Equations for Conical Shells. Joseph Kempner. *J. Aero. Sci.*, Feb., 1958, pp. 137, 138.

On the Buckling Problem of Shallow Spherical Shells Under External Pressure. H. J. Weinitschke. *J. Aero. Sci.*, Feb., 1958, pp. 134, 135. ONR-sponsored investigation.

Cylindrical Shells Under Line Load. R. M. Cooper. (*ASME Summer Conference, Berkeley, Calif., June 13–15, 1957, Paper 57—APM-28.*) *J. Appl. Mech.*, Dec., 1957, pp. 553–558. ONR-sponsored investigation using shell equations which include the effect of transverse-shear deformation. The results are in excellent agreement with those predicted by the Donnell equations for the stresses. The radial displacement, however, is in error by 20 per cent.

Behavior of Cylinders with Initial Shell Deflection. M. E. Lunchick and R. D. Short, Jr. (*ASME Summer Conference, Berkeley, Calif., June 13–15, 1957, Paper 57—APM-35.*) *J. Appl. Mech.*, Dec., 1957, pp. 559–564. Analysis of a cylinder subjected to external hydrostatic pressure using the mathematical expression for the initial deflection curve, resulting in expressions for the additional deflections and stresses caused by the initial deflection of the shell.

The Effect of Internal Pressure on the Buckling Stress of Thin-Walled Circular Cylinders Under Combined Axial Compression and Torsion. *J. Aero. Sci.*, Feb., 1958, pp. 142, 143.

On the Conservativeness of Various Distributed Force Systems. Sol R. Bodner. *J. Aero. Sci.*, Feb., 1958, pp. 132, 133. Study of three force systems and their properties with respect to the ring buckling problem. These force systems are: (1) hydrostatic pressure, (2) constant directional pressure, and (3) centrally directed pressure.

Elasticity & Plasticity

Concerning the Rigidity of Elastic Structures. M. Zaid. *J. Aero. Sci.*, Feb., 1958, pp. 141, 142. Analysis of some limitations of the theorem which states that adding material to any traction-free subsurface of a complex elastic structure results in a decrease in the deflection under each load, and vice versa.

On the Most General Form of the Compatibility Equations and the Conditions of Integrability of Strain Rate and Strain. Edmund H. Brown. *J. Res.*, Dec., 1957, pp. 421–426. Discussion of compatibility equations in terms of the material strain rate tensor and the rate of change of the Riemann-Christoffel curvature tensor during the deformations.

The Flow Function and the Yield Condition for Non-Homogeneous Orthotropic Bodies. W. Olszak and W. Urbanowski. *Acad. Pol. Sci. Bul.*, No. 4, 1957, pp. 191–203. Consideration of general notions of curvilinear orthotropy including elastic and plastic properties of the material.

Plates

Buckling of Rectangular Plates with Two Unsupported Edges. P. Shuleshko. (*ASME Summer Conference, Berkeley, Calif., June 13–15, Paper 57—APM-46.*) *J. Appl. Mech.*, Dec., 1957, pp. 537–540. Consideration of the elastic stability, tabulation of the nondimensional coefficient, and corresponding graphs.

Influence of Width on Velocities of Long Waves in Plates. D. C. Gazis and R. D. Mindlin. (*ASME Summer Conference, Berkeley, Calif., June 13–15, Paper 57—APM-29.*) *J. Appl. Mech.*, Dec., 1957, pp. 541–546. ONR-supported mathematical investigation carried out on the basis of approximate equations of motion.

Stresses in a Plate Under Tension and Containing an Infinite Row of Semi-Circular Notches. Akira Atsumi. *ZAMP*, Nov. 25, 1957, pp. 466–477. 10 refs. Analysis to determine the stresses in a semi-infinite plate under uniform tension having a row of an infinite number of semi-circular notches.

Stress Concentrations in a Strip Under Tension and Containing Two Pairs of Semicircular Notches Placed on the Edges Symmetrically. A. Atsumi. (*ASME Summer Conference, Berkeley, Calif., June 13–15, 1957—Paper 57—APM-41.*) *J. Appl. Mech.*, Dec., 1957, pp. 565–573. 14 refs.

Cylindrical Stress Waves in Flat Slabs. Norman Davids and Sudhir Kumar. *Quart. J. Mech. & Appl. Math.*, Nov., 1957, pp. 465–481. OOR-sponsored development of Goodman's solution for radially symmetric modes of stress wave propagation in infinite slabs, along with the determination of the various modes.

The Design of Intermediate Vertical Stiffeners on Web Plates Subjected to Shear. L. H. Mitchell and K. C. Rockey. *Aero. Quart.*, Nov., 1957, pp. 395, 396. Analysis in terms of Timoshenko's theory. It is concluded that the theory is valid only for the case where the stiffeners are placed along a straight node of one of the harmonics of the buckling pattern in the unstiffened plate.

Thermal Stress

Alleviation of Kinetic Heating Stresses. James Taylor. *Anglo-Am. Aero. Conf., 6th, Folkestone, Sept. 9–12, Paper.* 22 pp. Development of methods for reducing thermal stresses and material temperatures in aircraft structures. Includes a simplified empirical procedure for rapid analysis applicable to any preliminary design study.

Thermodynamics

Thermal Conductivity and Prandtl Numbers for Nonpolar Polyatomic Gases at High Temperatures. Eldon L. Knuth. *Jet Propulsion*, Dec., 1957, pp. 1,262, 1,263. Presentation of expressions for the calculation of the thermal conductivity coefficient and of the Prandtl Number.

Combustion

An Isotopic Tracer Study of Carbon Formation in Hydrocarbon Flames. R. E. Ferguson. *Comb. & Flame*, Dec., 1957, pp. 431–437. OSR-supported analysis of the hypothesis that acetylene is the last stable precursor to carbon in hydrocarbon flames. Results show that carbon does not arise from a two-carbon fragment of propane, and that if acetylene polymerization-decomposition is the mechanism of carbon formation, the acetylene involved is not a product of simple fuel-degradation.

Interpretation of the Sample Taken by a Probe in a Laminar Concentration Gradient. A. A. Westenberg, S. D. Raezer, and R. M. Fristrom. *Comb. & Flame*, Dec., 1957, pp. 467–478. Description of a theoretical study, and solution of the diffusion equation by the relaxation technique. Results indicate that the sample entering the sink has a composition differing slightly from that of the unperturbed case.

A Theory of Flame Propagation Limits Due to Heat Loss. E. Mayer. (*ARDE TN 4555–6*, June, 1957.) *Comb. & Flame*, Dec., 1957, pp.

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In the hypersonic regime, between Mach numbers of 6 and 30, the ideal gas concept of air must be abandoned.

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438–452. 19 refs. OSR-supported deduction of flame-propagation limit criteria for the special cases of convective heat loss applicable to flame quenching in a circular tube, and rediative heat loss applicable to free flames near the composition limit.

Studies in a New Type of Flat Flame Burner. William T. Biedler, 3rd, and H. E. Hoelscher. *Jet Propulsion*, Dec., 1957, pp. 1,257–1,260. Includes a detailed description of the design and performance characteristics of the device.

A Flow Reactor for High Temperature Reaction Kinetics. L. Crocco, I. Glassman, and I. E. Smith. *Jet Propulsion*, Dec., 1957, pp. 1,266, 1,267. OSR-sponsored description of the new device for the study of the reaction kinetics of propellants.

Studies on the Oxidation of Hydrocarbons Under Extremely Clean Experimental Conditions. Z. G. Szabó and D. Gál. *Comb. & Flame*, Dec., 1957, pp. 404–419. Experiments carried out in an all-glass apparatus, employing Bodenstein glass valves and a quartz manometer as a null instrument. Experimental curves are plotted, and the catalytic effects of water, iodine, methylamine, and nitric oxide are examined.

Eighth Quarterly Technical Status Report on Non-Stationary Surface Combustion Studies (Covering Period from 15 June 1957 to 15 Sept. 1957.) *ADC Rep. 410-R4/34*, 1957. 6 pp.

Heat Transfer

A Boundary Problem of Heat Conduction. W. Nowacki. *Acad. Pol. Sci. Bul.*, No. 4, 1957, pp. 205–212. Consideration of an elastic body with a steady concentrated heat source. The integral equations are reduced to a system of linear algebraic equations and solved in an approximate manner.

Heat Problems for a Laminar Stream Spreading Along a Wall. L. A. Vulis and A. T. Trofimenko. *Sov. Phys. - Tech. Phys.*, Oct., 1957, pp. 2,616–2,620.

Unsteady Heat Convection Near a Horizontal Cylinder. G. A. Ostroumov. *Sov. Phys. - Tech. Phys.*, Oct., 1957, pp. 2,627–2,641. 10 refs. Presentation of solutions obtained for a system of differential equations by successive approximations.

Tracks

The Holloman Track. *USAF MDC TR 57-1*, Sept., 1957. 17 pp. Description of the rocket-sled track and the related track facilities.

Captive-Dynamic Testing. *Missile Des. & Devel.*, Dec., 1957, pp. 15–17. Consideration of rocket-sleds as major development tools for modern guided missiles.

Designing a Rocket Sled. William E. Reynolds. *The Frontier*, Winter, 1957, pp. 17–20. Description of a sled designed to obtain a velocity of 2,000 ft./sec., and capable of firing rockets forward and rearward at angles from zero to 90° both in elevation and traverse.

VTOL & STOL

NACA Research on VTOL and STOL Aeroplanes. M. O. McKinney. *Anglo-Am. Aero. Conf., 6th, Folkestone, Sept. 9-12, 1957, Paper.* 27 pp. 34 refs. Discussion includes consideration of stability, control, and aerodynamics in hovering at low speeds.

High Lift for Naval Work. Terence R. F. Nonweiler. *Aeronautics*, Dec., 1957, pp. 25–27. Discussion of the application of various types of high-lift devices to ship-borne aircraft.

Water-Borne Aircraft

Investigation of High Length/Beam Ratio Seaplane Hulls with High Beam Loadings. XX—The Effect of Slipstream on Stability and Spray Characteristics. D. M. Ridland. *Gt. Brit., ARC CP 349* (Sept., 1955) 1957. 55 pp. 24 refs. BIS, New York, $1.35. Presentation of results, which show, that in general increases in thrust coefficient improved longitudinal stability, spray characteristics, and elevator effectiveness, as well as a method of applying these results to other models.

On Certain Integrals Occurring in a Hydrodynamical Problem. G. F. Miller. *Royal Soc. (London) Proc., Ser. A*, Dec., 1957, pp. 65–77. Development of a mathematical theory for certain integrals involving Bessel functions which occur in the problem of the movement of a planing wedge along a water surface.

Full Scale Measurement of Impact Loads on a Large Flying Boat (Sunderland Mk. 5). III—Data for Impacts on Main Step. IV—Data for Impacts on the Afterbody. V—Results of Rough Water Tests. R. Parker. *Gt. Brit., ARC CP 340; CP 341; CP 342*, 1957. 37; 37; 47 pp. BIS, New York, $1.08; $0.90; $1.35.

Wind Tunnels & Research Facilities

Testing Tomorrow's Aircraft. R. K. Collins and W. J. Walker. *Westinghouse Engr.*, Nov., 1957, pp. 189–193. Discussion of various types of wind tunnels and research facilities and of their use in research and development.

Development of a Piston-Compressor Type Light-Gas Gun for the Launching of Free-Flight Models at High Velocity. Appendix A—**Effects of Air Resistance and Bore Friction.** Appendix B—**Modifications to Performance Charts.** Appendix C—**Computational Procedure for Performance of Piston-Compressor Type Light-Gas Gun.** A. C. Charters, B. Pat Denardo, and Vernon J. Rossow. *U.S., NACA TN 4143*, Nov., 1957. 95 pp. 19 refs. Presentation of design for a gun capable of firing models at velocities up to 15,000 ft./sec. The firing trials show good agreement between predicted and measured velocities and pressures.

Ultrasonic Relaxation and Attenuation in Freons, in Relation to Their Use in Supersonic Wind Tunnels. Y. Miyahara and E. G. Richardson. *Gt. Brit., ARC CP 356* (Nov., 1956) 1957. 27 pp. 14 refs. BIS, New York, $0.72. Investigation into the use of freon for supersonic tunnels when it is desired to obtain a high Mach Number without great expenditure of power. It is shown that these vapours have ultrasonic relaxation times in the neighborhood of 10^{-7} sec., coupled with high-absorption coefficients in the ultrasonic range.

The Versatile Hurricane. Ward Lauren. *Skyline*, Winter, 1957, pp. 5–10. Description of North American's wind tunnel capable of speeds up to Mach 3.5.

Mechanical Design and Fabrication of Strain-Gage Balances. Raymond M. Hansen. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 9*, Feb., 1956. 14 pp.

Testing the Air-Breathers Turbojets and Ramjets "Fly" at Tullahoma. *CEC Recordings*, Nov.-Dec., 1957, pp. 12–14. Discussion of tests conducted in sealed test cells at altitudes from sea level to above 80,000 ft., at −120 to +650°F., and in a Mach Number range of 2 to 3.5.

Mesure et Enregistrement des Mesures sur les Balances Aérodynamiques à Jauges à Fil Résistant. M. Bassière. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 14*, Feb., 1956. 19 pp. In French. Development of a device for noting aerodynamic measurements which combines a recorder especially suitable for measurements using strain-gage bridges, with a coding device which enables the measurements to be noted or recorded on punched cards.

Elevated Stagnation Temperature and Strain Gauge Balances in the Instrumentation of a Supersonic Wind Tunnel. G. P. Tonkin. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 15*, Feb., 1956. 52 pp. 11 refs.

Evaluation and Calibration of Wire-Strain-Gage Wind Tunnel Balances Under Load. Raymond M. Hansen. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 13*, Feb., 1956. 17 pp.

The High-Altitude Test Plant. *Bristol Quart.*, Autumn, 1957, pp. 160–164. Description of a wind-tunnel for testing ramjets capable of providing conditions equivalent to speeds of more than Mach three and altitudes up to 90,000 ft.

Special Types of Internal Strain Gage Balances. T. L. Smith. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 7*, Feb., 1956. 11 pp.

Special Applications of Strain-Gage Balances Used in the Supersonic and Hypersonic Wind Tunnels at the U. S. Naval Ordnance Laboratory. James R. Lightfoot and Charles E. White. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 8*, Feb., 1956. 13 pp.

Development of a 400-CPS Servo Recorder. Ralph E. Klautsch. *USAF AEDC TN 57-47 [AD 144321]*, Dec., 1957. 20 pp. General description of the device, and a detailed explanation of various circuits used in this system. Certain developmental problems are also discussed.

Strain Gauge Balances for Wind Tunnels; an Outline of Practice in the United Kingdom. J. R. Anderson. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 5*, Feb., 1956. 67 pp.

A Note on a Half-Model Strain-Gauge Balance. N. C. Lambourne. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 11*, Feb., 1956. 7 pp. Description of a strain gage used at the British National Physical Laboratory, designed to measure four components on half models: normal force, longitudinal force, pitching moment, and rolling moment.

Problems Involved in Precision Measurements with Resistance Strain Gages. Keith H. McFarland and John Dimeff. (*NATO AGARD, 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 12*, Feb., 1956. 17 pp. 13 refs.

Some Strain Gage Balances Used in French Wind Tunnels. P. Rebuffet. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 6-T*, Feb., 1956. 64 pp.

Development of Half-Model Wind Tunnel Balances. (*NATO AGARD 8th Wind Tunnel and Model Testing Panel, Rome, Feb. 20–25, 1956.*) *NATO AGARD Rep. 10*, Feb., 1956. 35 pp. Description of three designs of half-model three-component balances. In all balances, strain gauge transducers are used for measurement of forces and moments.

Flow Visualization. A. M. Lippisch. *Aero. Eng. Rev.*, Feb., 1958, pp. 27–32, 36. Discussion of testing methods, and a description of two- and three-dimensional smoke tunnels.

Wind Tunnels Bolster America's New Sky Defense. M. D. Horton. *G-E Rev.*, Nov., 1957, pp. 33–38. Description of the wind tunnel facilities of the NACA at its three major laboratories and at the Air Force Arnold Engineering Development Center.

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Aeronautical Reviews — BOOKS

COMPUTERS

Faster, Faster; A Simple Description of a Giant Electronic Calculator and the Problems it Solves. W. J. Eckert and Rebecca Jones. New York, McGraw-Hill Book Company, Inc., 1955. 160 pp., illus., diagrs. $3.75.

Explanation, in nontechnical language, of how a calculator operates, the nature of the problems it solves, and how the problems are presented to the calculator. The calculator covered is the IBM NORC, designed and built for the Bureau of Ordnance of the U.S. Navy as a research and development project. It conforms to a pattern common to all large electronic calculators so that readers will be able to understand the operation of all calculators in this class.

The authors are affiliated with the Watson Scientific Computing Laboratory, Columbia University.

DICTIONARIES

Russian-English Glossary of Electronics and Physics. New York, Consultants Bureau, Inc., 1957. 354 pp. $10.

This glossary is a compilation of Russian terms used in the various specialized fields of electronics. It includes terms from thousands of pages of the most recent issues of Soviet journals, including *Automation and Remote Control, Journal of Technical Physics,* and *Radio Engineering and Electronics.* To this is added an appendix containing circuit notation, United States equivalents for vacuum tubes, and other information not found in other technical dictionaries.

DOCUMENTATION

Progress Report in Chemical Literature Retrieval; Based on Symposia of the Division of Chemical Literature, American Chemical Society, Held in Minneapolis, Minn., September, 1955, and in Dallas, Tex., April, 1956. Edited by Gilbert L. Peakes, Allen Kent, and James W. Perry. (Advances in Documentation and Library Science, Vol. 1.) New York, Interscience Publishers, Inc., 1957. 217 pp., illus., diagrs. $4.75.

Contents: (1) The Engineering Approach to Chemical Literature, James H. Wiegand and James W. Perry. (2) Elementary Punched-Card Principles, Harry C. Zeisig, Jr. (3) Contributions to the Theory of Automatic Information Retrieval, Ascher Opler. (4) Coding Several Types of Chemical Patent Abstracts, for Punched-Card Use, Elizabeth W. Tapia. (5) A Technical Information Service Using Punched Cards for Indexing and Retrieval, W. S. Jones and P. H. Butterfield. (6) Advances in Mechanization of Patent Searching, B. E. Lanham, J. Leibowitz, and H. R. Koller. (7) Patent Specification Machine Searching in the Field of Organic Chemistry, Henry L. Higginson and Anita Poplawska. (8) Experience with a Notched-Card File of Geochemical Data, Michael Fleischer. (9) Coding of Hammett Rho-Values on Punched Cards, H. H. Jaffé. (10) Two Approaches to the Retrieval of Information from a Special Library: (a) Application of a Simple Punched-Card System to a Special Information Center, Curtis L. Brown. (b) Application of the Uniterm System and the Association of Ideas to a Special Library File, Mortimer Taube. (11) The Unit Card System in the Indexing of Internal Technical Reports, Gilbert L. Peakes. (12) How Punch Cards Aid in Medical Research, Robert P. Gage. (13) Indexing of Fuel and Lubricant Additives by Machine-Sorted Punched Cards, Margaret H. Graham, Barbara S. Hildebrand, and B. H. Weil. (14) Statistical Survey of Chemical Structure, Karl F. Heumann and Estaleta Dale. Index.

ELECTRONICS

Industrial Electronics Handbook. R. Kretzmann. 2nd Ed. New York, Philosophical Library, 1957. 298 pp., illus., diagrs., tables. $12.

The first part of this book dealing with electronic circuits employing highly evacuated or gas-filled discharge tubes describes the principles and properties of the various classes of electronic tubes, together with typical applications and circuits. In the second part, a separate chapter is devoted to each of the main types of application, such as electronic relays, counting circuits, etc. A large number of practical examples are given; the operation of each being described in considerable detail with fully designed circuits.

The work aims to aid technicians engaged in the supervision or maintenance of industrial equipment, industrial engineers in the mechanical and electrical fields who desire to acquaint themselves with the possibilities of electronic control and the methods of application, and students at technical colleges and universities.

Industrial Electronics Circuits. R. Kretzmann. Translated from the German by D. J. Mitchell. New York, Philosophical Library, 1957. 194 pp., illus., diagrs. $10.

A sequel to the *Industrial Electronics Handbook,* this work describes the functions of some 200 various circuit elements and supplies comprehensive information on the actual component values. Instructive examples are given of photoelectric control devices, counting circuits for various purposes, stabilizing circuits, switching and control circuits, amplifiers and oscillators, rectifying circuits, and motor controls.

It is expected that the work will find application in all branches of the manufacturing industry and will also be of use to physicists, engineers, and technicians concerned with the development and design of electronic apparatus, as well as to students.

FLUID MECHANICS

Proceedings of the Fifth Midwestern Conference on Fluid Mechanics; Held at The University of Michigan, April 1–2, 1957. Ann Arbor, The University of Michigan Press, 1957. 388 pp., illus., diagrs., tables. $8.00.

Contents: Stability of Flows: (1) On Forced Oscillations in Rotating Fluids, Henry Gortler. (2) Effect of Chemical Reaction on the Inviscid Criterion for Laminar Stability of Parallel Flows, S. F. Shen. (3) On the Hydrodynamic Stability of Curved Laminar Compressible Flows, M. Lessen. *Laminar Flows:* (1) Laminar Convection of Heat from Two-Dimensional Bodies with Variable Wall Temperatures, C. R. Guha and Chia-Shun Yih. (2) Plane Couette Flow at Low Mach Number According to the Kinetic Theory of Gases, Hsun-Tiao Yang and Lester Lees. *Turbulent Flow:* (1) The Turbulent Velocity Distribution in Rough Pipe, James M. Robertson. (2) An Approximate Equation for the Mean Velocity Distribution in an Incompressible Turbulent Boundary Layer, Virgil A. Sandborn. (3) Turbulent Skin-Friction Measurements on a Smooth Flat Plate in Incompressible Flow, Donald W. Smith. (4) Incompressible Friction Factor, Transition and Hydrodynamic Entrance-Length Studies of Ducts with Triangular and Rectangular Cross Sections, E. R. G. Eckert and T. F. Irvine, Jr. (5) Heat-Transfer Characteristics of Periodically Pulsating Turbulent Pipe Flow, Wheeler K. Mueller. (6) Advances in Understanding the Mechanism of Turbulent Fluid Motion, Max M. Munk.

Supersonic Flows: (1) On a Mechanism for the Interactions of Plane Traveling Shock Waves Striking Rigid Grid-Like Structures Head-On, Harold O. Barthel. (2) The Pressure on a Blunt Trailing Edge Separating Two Supersonic Two-Dimensional Air Streams of Different Mach Number and Stagnation Pressure but Identical Stagnation Temperature, H. H. Korst and Wilson Tripp. *Hypersonic Flow:* (1) An Inverse Problem in Hypersonic Viscous Flow, Ting Yi Li. (2) Preliminary Test Results with an Arc-Heated Hypersonic Wind Tunnel at Mach Numbers of 10 to 20, W. N. MacDermott. (3) Flow in the Forward Stagnation Region of Blunt Bodies, Robert W. Truitt. *Magneto-Gasdynamics:* (1) One-Dimensional Unsteady Flow of Magneto-Gasdynamics, S. I. Pai. *Gas Jets in Liquids:* (1) Production of Bubbles by the Disintegration of Gas Jets in Liquid, Edward Silberman. *Slider Bearings:* (1) Numerical Methods of Solution of the Adiabatic Slider Bearing Without Side Leakage, Willis H. Guilinger and Edward Saibel. *Free Surface:* (1) Ellipse-Fitting Approximation of Two-Dimensional, Normal Symmetric Impact of Rigid Bodies on Water, Andrew G. Fabula. (2) The Waves Generated by the Forward Motion of Oscillatory Pressure Distributions, Paul Kaplan. (3) The Virtual Mass of Cylindrical Bodies at a Free Surface, Thomas E. Stelson and Joseph P. Murtha. *Marine Applications:* (1) A Simplified Theory for the Thrust Deduction Force on a Body of Revolution, John P. Breslin. (2) Lift and Wave Drag of Hydrofoils, A. G. Strandhagen and G. R. Seikel. *General Fluid Mechanics:* (1) The Dying Vortex, Albert de Neufville. (2) On the Possibility of the Formulation of a Quantum Fluid Dynamics Theory, M. Z. v. Krzywoblocki and C. G. Whittenbury.

Water Waves; The Mathematical Theory with Applications. J. J. Stoker. New York, Interscience Publishers, Inc., 1957. 567 pp., illus., diagrs. $12.

In presenting this connected account of the mathematical theory of wave motion in liquids with a free surface and subjected to gravitational and other forces, together with applications to a wide variety of concrete physical problems, the author has tried to plan the book in order that it should be as much as possible a self-contained and readable whole. The fundamental background in hydrodynamics is supplied, as is some of the mathematics needed.

Part I presents the derivation of the basic hydrodynamic theory for nonviscous incompressible fluids and also describes the two principal approximate theories which form the basis upon which most of the remainder of the book is built. Part II is based on the approximate theory which results when the amplitude of the wave motions considered is small. Part III is concerned with problems involving waves in shallow water, while Part IV deals with problems solved in terms of the exact theory—in particular, with the use of the exact nonlinear free surface conditions. The author is with the Institute of Mathematical Sciences, New York University.

GEOPHYSICS

Once Round the Sun; The Story of the International Geophysical Year. Ronald Fraser. New York, The Macmillan Company, 1957. 160 pp., illus., diagrs. $3.95.

This book will answer for many readers such questions as why an 18-month period was set aside for the International Geophysical Year and what we hope to learn through the coordinated efforts of scientists from 64 countries of the world. Highlighting the importance of the sun in the study of geophysics, the author covers all phases of the sun's behavior and its various effects on the earth. The book's detailed coverage of the IGY includes discussions of the 24-hour watch on the sun, the oceanographic program, and the concentration of stations from pole to pole and presents information on rocket and satellite plans. In summing up, the author shows how the increased knowledge which we expect to gain about upper and lower atmosphere will prove valuable in weather forecasting, agriculture, shipping, air navigation, and radio transmission.

The author is Administrative Secretary of the International Council of Scientific Unions, the nongovernmental organization which has sponsored the worldwide operation of the IGY 1957–1958.

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HYDRAULIC EQUIPMENT

7th Annual Aircraft Hydraulics Conference, Detroit, Mich., November 12–13, 1957. Sponsored by Aero Hydraulics Division, Vickers Incorporated, Detroit. Detroit, Witte & Burden, 1957. 283 pp., illus., diagrs.

Contents: Selection of Airborne Auxiliary Power Transmission Systems, Robert McJones. What Hydraulics Can Do, Frank Moncher. Optimizing the Hydraulic System Through High Temperature Compatibility, George Keller. Optimization Through a Load-Sensitive (Variable Pressure) Hydraulic System, William Patterson. Optimization Study of Hydraulic Transmission Lines, Robert McJones. Selection of Optimum Pressure, Conrad Cooke. Practical Experience With a 4000 PSI System, Bryan Wood. Optimizing Hydraulic Component Design, Charles Cannon. Optimization Through Integration of Sub-Systems, Edward I. Brown. Design and Operational Considerations for Contamination Control in High Performance Aircraft Hydraulic Systems, John Boucher. Clean Pumps for Clean Systems, Arthur Billet. The Caravelle Hydraulic System, Robert Blanchet.

INSTRUMENTS

Engineering Precision Measurements. A. W. Judge. 3rd Ed. London, Chapman & Hall, Ltd., 1957. 447 pp., illus., diagrs., tables. 65s.

As with the two previous editions, the scheme of the present book is to give a survey of the methods, machines, and instruments available for making the various engineering measurements coming within its scope. A considerable amount of new material has been included and some of the earlier matter deleted. In particular, four new chapters have been added, dealing with slip gages, straightness and flatness measurements, interferometry methods, and surface finishes. In view of the interest in automation, a brief account of automatic gaging and work-sizing is given.

The author is an Associate of the Royal College of Science, London.

MATERIALS

Engineering Materials Handbook. Prepared by a Staff of Specialists; Charles L. Mantell, Editor-in-Chief. New York, McGraw-Hill Book Company, Inc., 1958. 1,980 pp., diagrs., tables. $21.50.

Prepared as an aid to all concerned with the design, structure, and serviceability of engineering materials, this handbook makes quickly available technical tables, design information, structural characteristics, and tabular data and answers both routine and unusual problems that crop up whenever engineering materials are being selected. Throughout the book materials are considered from the viewpoint of engineering structures, machinery, and equipment, and the emphasis is placed on the fabricated forms of materials, their physical and mechanical properties, their adaptations, advantages, limitations, competition with each other, protection against deterioration, and increase in their stability to withstand use and abuse. In line with today's needs, the *Handbook* covers such items as the uncommon metals which are rapidly reaching commercial importance and production, and the materials of construction of apparatus of control and utilization of atomic forces and fission products.

The editor is Chairman of the Department of Chemical Engineering, Newark College of Engineering.

MATHEMATICS

Ordinary Difference-Differential Equations. Edmund Pinney. Berkeley, Calif., University of California Press, 1958. 262 pp., diagrs. $5.00.

In this work, which provides practical techniques for treating ordinary difference-differential equations, the author presents the practical theory of these equations, with progressively difficult examples of applications. An introductory section briefly indicating the nature and use of various methods of solution is followed by a development of the general theory of a wide class of equations and a discussion in detail of the infinite-series solution and methods of finding the roots of the characteristic equation. The author also specializes the general theory to deal with first- and second-order mixed difference-differential equations and treats numerous special equations, some of them quite recondite. It is believed that this book will be of special interest to electronic engineers, aeronautical engineers dealing with high-speed theory, mathematical economists, mathematical biophysicists, and applied mathematicians generally.

The author is Associate Professor of Mathematics, University of California, Berkeley.

Symposium on Design of Industrial Experiments; Held at North Carolina State College, November 5–9, 1956. Edited by Victor Chew. Conducted by the Institute of Statistics; Sponsored by the Air Force Office of Scientific Research. (AFOSR TN 57-778.) Raleigh, N.C., Institute of Statistics, 1957. 374 pp., diagrs., tables.

Presentation of 14 papers, grouped under three main headings: review of experimental designs useful in industrial research, industrial experi-

ences with experimental designs, and selected topics from recent research. A bibliography on the industrial applications of experimental designs (particularly fractional factorials and response surface-fitting methodology) is included.

MECHANICS

Proceedings of the Third Midwestern Conference on Solid Mechanics; Held at The University of Michigan, April 1–2, 1957. Ann Arbor, The University of Michigan Press, 1957. 250 pp., diagrs., tables. $5.50.

Contents: Pitching Instability of Rigid Lifting Surfaces on Viscoelastic Supports in Subsonic or Supersonic Potential Flow, Harry H. Hilton. On the Motion of a Thermo-Viscoelastic Solid, Martin Lessen. Approximate Yield Conditions in Dynamic Plasticity, P. G. Hodge, Jr., and Burton Paul. Damping of Vibrations in Elastic Rods and Sandwich Structures by Incorporation of Additional Viscoelastic Material, H. J. Plass, Jr. Thermal Stresses in an Infinite Plate of Arbitrary Thickness, E. L. McDowell. Elastic Stability of Conical Shells Loaded by Uniform External Pressure, C. E. Taylor. Torsion with Warping Restraint of Tapered Beams, Madeline Goulard, Hsu Lo, and R. J. H. Bollard. A Theoretical and Experimental Investigation of the Stability of a Hovering Helicopter Rotor Blade, John Zvara. Reflection and Transmission of Elastic Pulses in a Bar at a Discontinuity in Cross Section, E. A. Ripperger and H. Norman Abramson. The Timoshenko Beam on an Elastic Foundation, Stephen H. Crandall. On Rotating Blades with Flexible Mounting, Hsu Lo and C. E. Danforth. The Bending Vibrations of a Twisted Rotating Beam, Walter P. Targoff. Effect of Damping on Vibration Frequencies of Simple Systems, L. E. Malvern. Bending-Torsion Flutter Sensitivity in Incompressible and Supersonic Flow, A. S. Richardson, Jr. Flutter of Curved Plates with Edge Compression in a Supersonic Flow, Y. C. Fung.

METEOROLOGY

The Physics of Clouds. B. J. Mason. Oxford, Eng., The Clarendon Press, 1957. 481 pp., illus., diagrs., tables. $11.20.

The publishers consider this to be the first comprehensive and detailed account of modern researches, both experimental and theoretical, on the microphysical processes of nucleation, condensation, droplet growth, initiation and growth of snow crystals, and the mechanisms of precipitation release. It also includes a critical appraisal of the present status of rainmaking experiments and chapters dealing with radar studies of precipitating clouds and the electrification of clouds. As a textbook, it is designed to give the student the necessary background to carry out independent work. As a reference book for the research worker, it provides an integrated account of the major developments in this field. Although written primarily for the atmospheric physicist, it contains much of interest for those in the fields of nucleation phenomena, crystal growth, and aerosol physics.

The author is with the Department of Meteorology, Imperial College of Science and Technology, London.

NAVIGATION

The American Flight Navigator. John Dohm. North Hollywood, Calif., Pan American Navigation Service, 1958. 352 pp., illus., diagrs., tables. $6.50.

Developed for the layman and student, this complete but concise study of the methods and equipment used in international transport navigation emphasizes operations of United States flag carriers. Chapters are included not only on the traditional methods of long-range navigation (such as dead reckoning, celestial, radio, and loran) but also on such new and forthcoming techniques as Doppler navigation and Navarho. Polar navigation and jet-transport navigation are also treated.

A special feature of the book is the presentation of the comprehensive written examinations (plus answers, plotting charts, Almanac excerpts, Civil Air Regulations, and all other necessary working material) designed to prepare students for the CAA's civil Flight Navigator Certificate.

The author is Editor of the *Journal of the Institute of Navigation.*

PHYSICS

Solid State Physics; Advances in Research and Applications, Vol. 5. Edited by Frederick Seitz and David Turnbull. New York, Academic Press, Inc., 1957. 455 pp., diagrs., tables. $11.

Partial Contents: Galvanomagnetic and Thermomagnetic Effects in Metals, J.-P. Jan. Luminescence in Solids, Clifford C. Klick and James H. Schulman. Space Groups and Their Representations, G. F. Koster. Shallow Impurity States in Silicon and Germanium, W. Kohn. Quadrupole Effects in Nuclear Magnetic Resonance Studies of Solids, M. H. Cohen and F. Reif. Author Index. Subject Index.

The Relativistic Gas. J. L. Synge. Amsterdam, North-Holland Publishing Company; New York, Interscience Publishers, Inc., 1957. 108 pp., diagrs. $4.50.

The purpose of this book is to develop in a simple way some formulas for a relativistic gas—that is, a system of material particles (and perhaps photons) which, by elastic collisions between them, take up certain equilibrium distributions. The author, who is with the School of Theoretical Physics, Dublin Institute for Advanced Studies, has developed his subject from the point of view of the relativist seeking knowledge about gases rather than for the expert in statistical mechanics who wishes to delve into relativity.

Contents: I. Geometrical Preliminaries. (1) The Scope of the Theory. (2) Momentum 4-Space. (3) The Absolute 2-Content of a 3-Cell of a Pseudosphere. (4) The Absolute 2-Content of a 3-Cell of the Null Cone. II. The Distribution Function. (5) The Distribution Function for a Discrete Complex of World Lines. (6) Invariance of the Distribution Function. (7) The Distribution Function in the Case of No Collisions. (8) Velocity-Space. (9) Complete Chaos and Equal a Priori Probabilities. III. Energy Tensor, Numerical Flux-Vector, Entropy Integral. (10) The Energy Tensor. (11) The Numerical Flux-Vector. (12) The Entropy Integral. IV. Distribution Function for a Simple Gas or a Mixture. (13) The Distribution Function for a Simple Gas. (14) The Distribution and Equations of Motion for a Simple Gas Composed of Material Particles. (15) The Distribution and Equations of Motion for a Simple Gas Composed of Photons. (16) The Distribution and Equations of Motion for a Mixture. V. Temperature, Most Probable Speeds, Distribution of Energy. (17) Temperature and Effective Temperature. (18) The Most Probable Speed for a Material Particle and the Most Probable Frequency for a Photon. (19) Distribution of Energy in a Mixture of Gases. VI. First Integrals, Adiabatic Laws, Equipartition. (20) First Integrals of the Equations of Motion. (21) The Adiabatic Laws. (22) Averages and Equipartition. VII. Shock Waves. (23) Wave Velocity. (24) Shock Waves in a Relativistic Gas. (25) The Speed of a Shock Wave. (26) The Speed of Sound. (27) Thermodynamics. (28) The Irreversibility of Shocks. (29) Some Inequalities for Bessel Functions. Appendix: The Radiation Field in a Moving Gas.

REFERENCE WORKS

Van Nostrand's Scientific Encyclopedia. 3rd Ed. Princeton, N.J., D. Van Nostrand Company, Inc., 1958. 1,839 pp., diagrs., illus., tables. $30.

This greatly enlarged and completely revised third edition of a standard one-volume scientific and engineering encyclopedia defines and explains some 15,000 terms of fundamental interest. These are arranged alphabetically, and an extensive system of cross-indexing has been developed to enable the reader to find the substantive facts that bear directly on each topic included.

The fields covered are aeronautics, astronomy, botany, chemical engineering, chemistry, civil engineering, electrical engineering, electronics, geology, guided missiles, mathematics, mechanical engineering, medicine, metallurgy, meteorology, mineralogy, navigation, nuclear science and engineering, photography, physics, radio and television, statistics, and zoology.

Because of the progressive development of the discussion of each topic—i.e., beginning with a simple definition expressed in the plainest of terms and progressing to a discussion in technical terms of the more detailed aspects of the topic treated—those articles of a highly technical nature may be of value both to the inquiring lay reader and to the trained technician. Articles dealing with simple concepts are, of course, treated generally in simple terms.

Although the publishers are aware that any one-volume work cannot be all-inclusive, they feel that the comprehensiveness of the book is noteworthy both in the scope of the terms covered and in the breadth of the treatment in the individual article, and that it is a book to be kept on the shelf with the few basic volumes that are used everywhere for essential day-to-day reference.

REPORT WRITING

Technical Report Writing. James W. Souther. New York, John Wiley & Sons, Inc., 1957. 70 pp., diagrs., tables. $2.95.

This book makes available to undergraduates and practicing engineers alike a short, concise, yet broad treatment of the fundamentals of technical writing. The treatment is basically a design approach: the principles of engineering design, translated to the terms of writing, are applied to the solution of reporting problems. The book emphasizes method and centers on the writing process; it stresses the factors the writer must consider and the processes he must follow in writing a report. Report form is related to the use to be made of the report, and report layout is presented as a design tool, representing a graphic extension of the organization of the material in the report.

The author is Associate Professor of Humanistic-Social Studies and Assistant Dean, College of Engineering, University of Washington.

THERMODYNAMICS

Heat Transfer, Vol. 2. Max Jakob; with the Technical and Editorial Assistance of Stothe Peter Kezios. New York, John Wiley & Sons, Inc., 1957. 652 pp., diagrs., tables. $15.

In this continuation of his attempt to present the subject of heat transfer in great detail from the combined viewpoints of the engineer, physicist, and mathematician, the author deals mainly with selected fields of heat-transfer application. He also offers a comprehensive analysis and discussion of heat radiation in spaces of simple configuration. Material in the first volume which needs additions or modifications as a result of later developments is brought up to date in a section entitled "Supplements to Volume I."

Thermodynamics of One-Component Systems. William N. Lacey and Bruce H. Sage. New York, Academic Press, Inc., 1947. 376 pp., diagrs., tables. $8.00.

Designed to aid the engineering student in applying his knowledge to the solution of the everyday problems of the engineer, this work is limited to a consideration of systems consisting of only one molecular species and not involving the appearance of new species or the disappearance of that which was originally present. Chemical changes are not considered, nor are all of the possible so-called physical changes discussed. Since one of the purposes of the book is to familiarize the student with the use of his knowledge in terms of engineering units, they are used throughout the book in both discussions and problems.

Both of the authors are associated with the Chemical Engineering Laboratory, California Institute of Technology, Pasadena.

VIBRATION

Mechanical Vibrations. Austin H. Church. New York, John Wiley & Sons, Inc., 1957. 275 pp., diagrs., tables, $6.75.

A mathematical and physical treatment of the basic principles of vibration analysis which, at the same time, lays the foundation for advanced work in this area. Specific topics covered include forced vibrations of multimass systems, harmonic analysis, torsional critical speeds, electrical analogies, coupling action, and balancing of angle or vee engines.

The author is Professor of Mechanical Engineering, New York University.

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Scientist Wayland Marlow III, right, adjusts an interferometer used for optical study on shock tube air flow. Dr. Daniel Bershader, center, Manager Gas Dynamics Department, checks operation at the control panel with scientist Jerry D. Kennedy.

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